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ASPIRATION OF AMNIOTIC FLUID BY THE FETUS

An Experimental Roentgenological Study in the Guinea Pig

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ALTHOUGH it is commonly said that the fetus is apneic *in utero*, this concept has been challenged from time to time. Some investigators hold that it exercises its breathing mechanism before the end of gestation. How extensively fetal respiration-like movements occur under normal physiological conditions is the subject of some controversy at present.

No one doubts that mammalian fetuses can perform rhythmical movements of their respiratory muscles long before birth but these may be due to asphyxia or at least to conditions involving a higher degree of anoxemia in the fetal brain than normally obtains there. Such movements are commonly seen when the uterus of a pregnant laboratory animal is opened. The literature contains many reports all of which we shall not review here. Human fetuses show the movements in question as early as the twelfth week of gestation when the placental exchange is interrupted (23). On the basis of similar observations one may be tempted to entertain a false conception of respiration at birth as a continuation of respiration-like motor phenomena indulged in normally by the fetus throughout fetal life. This is contrary to fact.

Using the cat as an experimental animal, we (24) were able to demonstrate that fetuses are apneic *in utero* during the third quarter of gestation (the gestation period lasts 65 to 69 days in the cat) but they respond to increasing the carbon dioxide and decreasing the oxygen tensions in their blood with rhythmical respiration-like movements. In our experiments, anesthesia was avoided, the pregnant animals having been decerebrated by ligating the carotid and basilar arteries according to the method of Davis and Pollock (16) an hour or more before experiments were begun. The cat experiments were confirmed in incubating eggs of the chick and duck (25, 26, 27). It was possible to control physiological conditions more precisely in the bird than in the mammal. A comparison of our studies with those of Romijn and Roos (18), who have determined the oxygen and carbon dioxide content of the atmosphere breathed by the chick (egg air-space), shows that the occurrence of respiratory movements is associated with anoxemia.

Other investigators have studied the respiration-like activities of young mammalian fetuses. Barcroft and Barron (3) saw such

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movements in the sheep and one of the present authors (W. F. W.) had the good fortune to observe some of their experiments. Although it may be thought that their observations support the view that fetuses normally are not apneic *in utero*, these authors avoided such conclusion. They considered the possibility that "some as yet ill understood stimulation of the fetus" started them. At any rate, the movements made their appearance under experimental conditions and one has no way of knowing if they occur normally in the intact sheep. The ewes had been anesthetized with urethane or had been given a spinal anesthetic before the experimental cesarean sections were performed. The first respiration-like movements of 38 to 40 day old fetuses may have been set off by mechanical pressure upon the amniotic sac. Later, spontaneity of the rhythmical movements became more pronounced but stimulation still facilitated their observation. In at least one instance they were observed through the wall of the trans-illuminated but manipulated uterus. In another study from the Cambridge laboratory (5), it has been shown that at the tenth week of gestation the fetal blood drawn anaerobically from the umbilical vein of exposed goat fetuses is no more than 60 per cent saturated with oxygen, percentage saturation increasing with age to the seventeenth week. If the young sheep fetus does appear to be "breathing" continuously *in amnio*, it may be because its blood, like that of the goats studied under similar experimental conditions, was deficient in oxygen. That is, the experimental conditions may have led to anoxemia. Spontaneous movements of a respiratory nature are no longer seen when sheep fetuses reach about 50 days gestation age (4) and the unborn lamb near term is singularly quiet in the unopened uterus. Correlatively, it has recently been shown that the umbilical vein blood drawn without opening the uterus often exceeds 90 per cent saturation with oxygen (6).

What other evidence is there for the belief that respiration at birth is simply a continuation of respiration-like activity occurring normally before birth? Ahlfeld (1) started a lively discussion of this question more than half a century ago when he described certain activities of the human fetus which he could observe by watching the abdomen of the mother in the latter part of gestation. Many expressed doubts that these were truly of a respiratory nature. In 1905 he (2) published excellent graphic records that can leave no question in our minds that what he saw resulted from rhythmical movements of fetal respiratory muscles. Reifferscheid confirmed his observations but concluded that the movements did not necessarily cause amniotic fluid to be aspirated by the fetus. Recently, Snyder and Rosenfeld (20) have produced motion pictures of these human fetal respiratory phenomena. They hold them to be physiological and to bring about a flow of amniotic fluid into and out of the fetal lungs *in amnio*, even suggesting that such aspiration may assist in opening the lung aveoli preparatory to air breathing at birth. Be that as it may for the moment, the outstanding fact of the case is that human fetal respiration-like movements are only rarely seen and when they are they appear at very infrequent intervals. This is similarly true in certain other mammals that have been studied recently.

Snyder and Rosenfeld (21) described rhythmical respiration-like movements in late fetal life of other mammals, principally rabbits. The pregnant animals were submitted to spinal cord section previous to experiments and the abdomens were opened in a bath of warm saline solution to allow direct observation of the intact uteri. Analysis of their data shows that intermittent rhythms of activity were seen in somewhat more than 19 per cent but less than 56 per cent of their specimens. The majority of the rabbit fetuses studied were at term (31 days) or were postmature, the gestation period having been prolonged hormonally one or more days. It is probable that the post-mature fetuses failed to obtain a normal oxygen supply and may have shown respiratory movements for this very reason. Koff and Davis reported that the fetuses of rabbits in which labor was inhibited by similar methods failed to live beyond the thirty-sixth day of gestation. Perhaps they died of asphyxia. On the other hand, in the untreated specimens at term there can be no doubt that

respiration-like rhythms do manifest themselves occasionally. Snyder and Rosenfeld have informed us that they were able to see what appeared to be respiratory movements in fetuses in a few unoperated upon, untreated rabbits, near term.

Bonar and Blumenfeld repeated some of the experiments to which we have referred. They stated: "We have come to the conclusion that intra-uterine respiratory movements of the fetus occur, that they are physiological, and that they are not initiated by asphyxial changes in the fetal blood nor by stimulation as a result of handling." Proof is lacking for such a broad statement.

Recently we have examined more than 25 perfectly healthy, unoperated upon, pregnant cats and guinea pigs carrying normal litters near term and have not been able to observe clearly defined respiration-like movements. It seems clear to us that such activities must be less prevalent than we formerly believed (22). However, it is sometimes possible to palpate and to see fetal movements of a respiratory nature without opening the abdomen of a decerebrate cat (24). They are infrequent, inconstant, and not in all animals are they manifested. After the uterus has been delivered, the cat submerged in a bath of warm Ringer-Locke solution, they can be seen to good advantage. The longer the uterus has been exposed, as a rule, the more frequently the fetal activities in question occur. Great caution must be exercised in evaluating results of experimentation.

Blood-gas analyses have been made from samples withdrawn from the umbilical veins of cat fetuses delivered from the uterus but still with placental circulation intact (22). It was found that the content of oxygen was low, not exceeding about 50 per cent saturation in the blood of specimens which were executing rhythmical respiratory movements at the time of sampling. It has not been possible to obtain samples from the umbilical veins without incising the uterus and consequently we do not know what the oxygen level is *in utero*. However, it was apparent that the veins darkened very quickly upon delivering a cat fetus and before we could draw blood from them. Fetal respiratory efforts often began at that time. In the human at normal birth when apnea prevails but respiration starts readily, the umbilical vein blood is about 50 per cent saturated with oxygen (11). Some higher values have been obtained at cesarean section (11) and at normal delivery (8) in the human. In the cow, too, a higher degree of oxygen saturation seems to prevail (19). The sheep fetus a few days from term is apneic *in utero* and correlatively, its umbilical vein blood, obtained without removal of the lamb from the uterus, is highly saturated, exceeding 90 per cent in some (6). But when the lamb is delivered in a saline bath with placental circulation intact, the blood becomes reduced until it is only about 35 per cent saturated in the fetal carotid artery (7). In the bird, respiratory movements normally begin several days before hatching at the time when the atmosphere of the egg air space, into equilibrium with which the "avian placental" blood comes, has become reduced in oxygen to about 13 volumes per cent while the carbon dioxide has increased to 6.5 volumes per cent (18). The figures for fertile unincubated eggs are about 20 volumes per cent and 1.5 volumes per cent, respectively.

These facts seem to indicate that the fetus is apneic *in utero* (or *in ovo*) so long as it is receiving a certain adequate amount of oxygen and is giving up carbon dioxide satisfactorily. When and if the fetal requirements exceed the placental capabilities in these respects the fetus may respond with rhythmical movements of a respiratory nature. That the conditions for fetal respiration-like activities are occasionally met in what appears to be the normal course of events prior to birth can not be doubted. However, there is no proof that they are ever met in all or even in the majority of individuals.

Granting that respiration-like movements can and do occur occasionally *in utero* toward the end of gestation, what is the evidence that the fetus aspirates its amniotic contents? Others have pointed out that dyes injected into the amniotic sac can be observed in the fetal lungs after removal of the fetuses (20, 28). In none of these experiments have anoxial conditions been rigidly ruled out of consideration. It is known that vernix caseosa

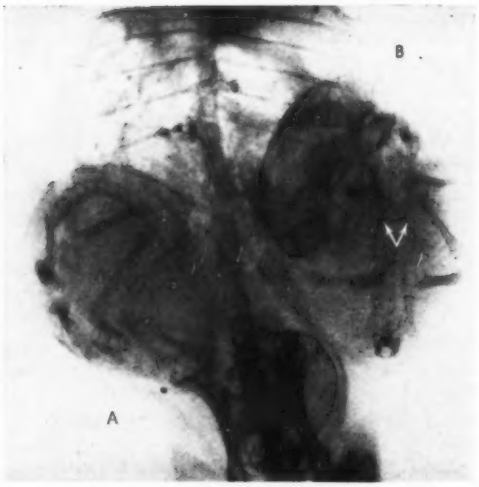


Fig. 1. The abdomen of the pregnant guinea pig was opened after infiltrating the tissues with 1 per cent procaine on the sixty-third day of gestation. Amniotic fluid was withdrawn from the sacs of the two fetuses and replaced with an equivalent amount 0.8 c.cm.) of thorotrast in A and thorad in B. The pregnant animal then was allowed to breathe an atmosphere low in oxygen and high in nitrogen. Respiration-like rhythms of fetal movements were observed through the uterine wall in B but were not so clearly seen in A. The roentgenogram taken half an hour later shows the bronchial tree well filled with thorad in B but not in A.

is sometimes found in the lungs of infants which have survived birth a short time. However, Farber and Sweet, in a large series of autopsies with microscopical study, found that only 15 per cent of the lungs of human infants surviving birth for 5 weeks or less contained significant amounts of débris, ascribable to fetal aspiration of amniotic contents.

RESULTS

We wish to report at this time some new experiments bearing upon the question of aspiration of amniotic fluid. Taking our cue from Ehrhard, who recently demonstrated fetal swallowing by means of roentgenograms taken after injecting thorotrast into the amniotic sac of one human subject, we have studied a series of guinea pigs during the last week or two of gestation. The procedure follows: The pregnant animals were tied to an operating board upon their backs and the position of the fetal heads determined by palpation. Without an anesthetic we were able to pierce the abdominal and uterine walls with a thin (No. 27) hypodermic needle. Usually from 0.4 to 1 cubic centimeter of amniotic fluid was withdrawn and an equal amount of a colloidal solution of thorium hydroxide or dioxide (thorad or thorotrast[1]) was injected to replace it through the same needle. In a few instances the material was injected without withdrawing any amniotic fluid. The injection was made as near the nostrils and mouth of the fetus as possible; often we could feel the teeth with the tip of the needle. After injection, roentgenograms were obtained within a few minutes, a few hours, and then at daily intervals until birth.

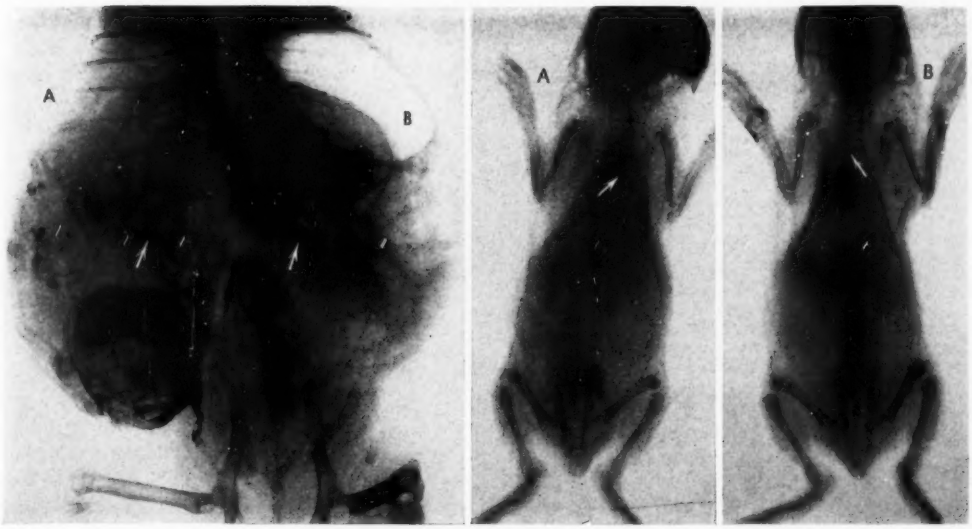
TABLE I.—FETAL ASPIRATION IN EXPERIMENTAL ANOXEMIA

No.*	Age (days)	Gas breathed	Fetal respiration observed	Presence or absence of lung shadows
1	63	Nitrogen	+	+
2	63	Nitrogen	+	+
3	60	Nitrogen	+	–
4	64	Nitrogen	Slight	–
5	64	Nitrogen	Slight	–
6	62	Nitrogen	?	–
7	66	Nitrogen	?	?
8	66	Nitrogen	?	–
9	67	Nitrogen	+	+
10	67	Nitrogen	?	–
11	67	Nitrogen	?	–
12	61	Rebreathing	+	–
13	61	Rebreathing	Weak	–
14	62	Rebreathing	Weak	–
15	65	Nitrogen	+	–
16	65	Nitrogen	+	+
17	65	Nitrogen	+	+
18	63	Nitrogen	–	–
19	63	Nitrogen	+	+
20	63	Nitrogen	?	?
21	67	Carbon dioxide	+	+
22	67	Carbon dioxide	?	+
23	58	Carbon dioxide	Slight	+
24	58	Carbon dioxide	Slight	–
25	52	Carbon dioxide	–	–

*Injections were made in intact animals 1 to 14 and at laparotomy in animals 15 to 25.

Results can be described very briefly. Twenty-seven fetuses (20 pregnant guinea pigs) 51 to 72 days gestation age (birth usually occurs between 65 and 68 days in this species) were treated as indicated. In 10 of these, only 1, 2, or 3 films were taken and exposures were made only within the first few hours after thorium hydroxide or dioxide

[1]We wish to acknowledge the generosity of the General Electric X-Ray Corporation and the Heyden Chemical Corporation who supplied these materials for experimental purposes.



Figs. 2 and 3. Experiment similar to that in Figure 1, but using 1 cubic centimeter of thorad in two amniotic sacs on the sixty-seventh day of gestation. The pregnant animal then breathed an atmosphere with a high carbon dioxide content. Figure 2 is a roentgenogram taken 40 minutes later. It shows the bronchial tree in fetus A and the trachea in B outlined by the thorad which was aspirated. Figure 3, taken after removing the fetuses, is confirmatory.

had been introduced. In the 17 other fetuses, the material was present in the amniotic sacs for periods varying from 24 hours to 14 days and from one to many exposures were made at daily intervals or less. In no instance could trachea, bronchi, or lungs be seen in the roentgenograms although the opaque substance could be observed in the fetal stomach within an hour or more by virtue of the fact that it had been swallowed.[1] We concluded that the fetuses either had not aspirated the thorium hydroxide or that this substance was too dilute when drawn into the lungs to cast a shadow on our films. These results were similar to those obtained by Ehrhard in his one 6-month human fetus which showed no lung shadow. Menees, Miller and Holly (10, 15) apparently found the same if we may judge from an illustration showing the fetal stomach filled but the chest without shadows. Menees and his colleagues, who pioneered in amniography, used a solution of strontium iodide instead of thorotrast. Access to six human roentgenograms taken after using diotrast (on the service of Dr. Cornell at Passavant Hospital) failed to demonstrate any shadows of the respiratory tract. However, strontium iodide and diotrast are of much less value than thorotrast for our present purpose. We would emphasize the point that in our own experimental animals conditions were as nearly normal as we would make them: no anesthesia was used, excessive palpation was avoided, only very small quantities of a material which does not pass through membranes and seems to be quite inert were used, and usually this was administered in such a way that no change in fluid volume *in amnio* was effected. The significance of our negative results will become apparent from the experiments which follow.

To test the questions raised by these observations we performed another series of 25 experiments in 18 fetuses (12 pregnant guinea pigs) 52 to 68 days gestation age. In 14 experiments, initial conditions were exactly like those outlined, but in the 11 other experiments injections were made after the mother's

[1] We shall deal with the subject of fetal swallowing and gastro-intestinal activities in another article to appear in this journal in the near future.

Figs. 4 and 5. One cubic centimeter of thorotrast replaced a similar volume of amniotic fluid withdrawn from one sac of an unanesthetized guinea pig on the sixty third day of gestation. Figure 4 is from the film taken on the sixty-sixth day; it shows clear lungs but thorotrast in the intestines. The guinea pig died 5 days after the injection and the fetus whose amniotic sac contained the thorotrast was recovered at autopsy. Figure 5 shows heavy shadows of the thorotrast-filled lungs.

abdomen had been opened following procaine infiltration of tissues. In all 25 experiments after injection had been made, the pregnant guinea pigs were subjected to procedures designed to change the gas tensions of the fetal blood. Usually, films were exposed before such changes had been effected; all such films showed the fetal respiratory tracts clear. Following this, the pregnant animals were allowed to breathe atmospheres high in nitrogen or carbon dioxide or were forced to rebreathe air from a rubber glove placed over the head. The fetuses became active in consequence of these procedures and we could usually observe rhythmical fetal movements resembling respiration, although it was frequently very difficult to be certain of the nature of these activities. Subsequently, roentgenograms were obtained again to determine whether or not aspiration of the thorium hydroxide had occurred. Table I summarizes the results of these experiments made with animals.

It will be seen that the lungs were more prone to fill with the material when injected at laparotomy than when given to the intact animals. Interference with uterine vascular channels may have added to the severity of the anoxemia in these experiments. In the 14 experiments showing weak, questionable, slight, or no fetal respiratory movements of a rhythmical nature only two definite fillings of the fetal respiratory tract occurred. In the 12 remaining experiments, all showing fetal respiration-like rhythms clearly, 7 perfectly definite and positive results were obtained.

Three additional experiments, not included in the 25 just mentioned, throw light on the question of the aspiration by the fetus. In one, the amniotic sac was injected with 0.8 cubic centimeter thorotrast on the sixtieth day of gestation. X-ray films subsequently demonstrated that the fetal respiratory tract contained no opaque material. During the following day the guinea pig appeared to be in labor which was prolonged throughout the

morning. Death of the mother occurred at noon without delivery. A roentgenogram of the fetus at this time revealed the lungs filled with thorotrast. In another instance, 1 cubic centimeter thorotrast was added to the amniotic fluid of one fetus on the sixty-third day of gestation. Films taken thereafter revealed no lung shadows (Fig. 4). The mother died during the night 5 days later without delivering the fetus. A film of the fetus subsequently demonstrated that the fetal lungs had become filled with thorotrast (Fig. 5). Finally, 2 of 4 fetuses in the uterus of one animal were injected on the sixty-first day of gestation. Three roentgenograms taken on the sixty-first, sixty-second, and sixty-third days showed the lungs of both fetuses to be perfectly clear. Birth occurred on the sixty-fourth day. One of the injected fetuses was born alive and the other failed to breathe at birth. The lungs of the living fetus were perfectly clear (Fig. 6 *a*), while those of the one failing to breathe after birth had become filled with thorotrast as may be seen in Figure 6 *b*.

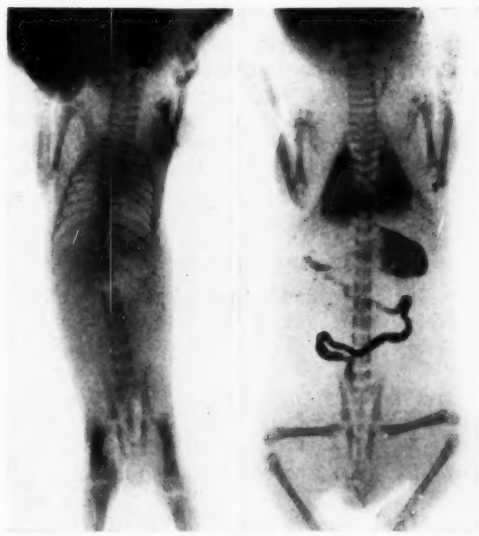


Fig. 6. Thorotrast was placed in the amniotic sacs of two fetuses on the sixty-first day of gestation without using anesthesia. Daily roentgenograms showed that the lungs of neither fetus contained any of the material, although it was present in the gastro-intestinal tract. Birth occurred on the sixty-fourth day. Fetus A was alive at birth and its fur was found coated with meconium and thorotrast. Its lungs were clear. Fetus B died without breathing at birth. Its lungs were filled with the thorotrast. Considerable time elapsed between birth and the exposure of these films and the living pig, A, had had time to pass whatever thorotrast remained in the gastro-intestinal tract at birth.

ANALYSIS OF RESULTS

It would seem from these experiments that aspiration of amniotic contents does not occur normally in the guinea pig fetuses but that it may be brought about under conditions of asphyxia. It is furthermore suggested that not all fetal movements which appear to be rhythmical and resemble respiratory activity serve to bring about aspiration of amniotic fluid. There is no reason to think that conditions of placental exchange are very different in the guinea pig and man but just how far one can go in the direction of interpreting human fetal respiratory behavior in terms of our present experiments is problematical. Certainly it may be said that the presence of vernix, laguno hair, or other débris in the lungs of the human newborn is unphysiological. It is very doubtful if amniotic fluid can be aspirated without bringing such débris into the respiratory tract. The Farber and Sweet studies have indicated very clearly that lungs of few infants, even of those surviving birth but a few hours, contain vernix caseosa. It is reasonable to assume that in the few cases in which vernix appeared in the lungs, respiratory acts had been induced prematurely by some unphysiological condition. From our experience with guinea pigs it would seem that inhalation of gases which induce anoxemia may lead to prenatal aspiration of amniotic contents. The implication is that asphyxial types of anesthesia may do the same.

Since we found experimentally that the lungs do not invariably become filled with fluid when the guinea pig fetus executes rhythms of movements resembling respiration, it may be taken that in the human, too, the observation of Ahlfeld's fetal respiration-like movements before labor sets in does not necessarily signify that the fetus is aspirating amniotic fluid. However, the prevalence of such fetal behavior should be looked upon with apprehension because we know that it may mean inefficiency in the placental

exchange mechanism which can lead to anoxemia and consequently aspiration of vernix caseosa. If the human, like other mammalian fetuses, is normally apneic *in utero*, and responds as they do to oxygen deficiency and carbon dioxide accumulation, there is no reason to doubt that fetal respiration-like movements do signify that fetal needs are not being met advantageously.

CONCLUSIONS

1. Intra-uterine rhythmical respiration-like movements of guinea pig fetuses were not observed under normal physiological conditions.

2. Thorotrast or thorad introduced into the amniotic fluid about the head of the fetal guinea pigs in late prenatal life was not aspirated by the fetuses when physiological conditions prevailed.

3. When fetuses were induced to execute rhythms of respiration-like movements during experimental anoxemia the amniotic fluid containing thorotrast or thorad was aspirated in some, but not all, instances. Similarly, difficulty in labor with consequent fetal asphyxia led to aspiration of amniotic fluid by the fetuses in several instances.

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AN EXPERIMENTAL STUDY OF URETERO-INTESTINAL IMPLANTATION

II. The Significance of the Normal Ureterocloacal Arrangement in Some Reptiles and All Aves

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AS AN approach to the surgical problem of uretero-intestinal anastomosis, the normal structure of the ureterocloacal entrance, as found in some reptiles and all birds, has been investigated. Examinations were made of gelatin injections, gross preparations, and microscopic sections of the urinary cloacal tract in the alligator, chicken, duck, turkey, and ostrich. In 6 chickens and 2 ostriches the entire intramural extent of the ureter was sectioned serially. All of the animals studied exhibited similar anatomical structures, but the following description refers specifically to chickens weighing approximately 3 pounds.

Ureter. The ureter averages 2 millimeters in diameter and 6 centimeters in length. Taking origin from a ventrally located renal pelvis it pursues a retroperitoneal course to transpierce the wall of the cloaca and empty into the urodeum by way of orifices which are situated in the dorsolateral aspect of the vestibule. As the ureters approach their intramural extent they gradually converge to the ureterocloacal orifices which are located about 1 centimeter apart (Fig. 1).

Upon histological examination, the ureter is found to be composed of 3 layers, the mucosa, the muscularis, and the adventitia, progressing from the lumen outward (Fig. 2). The mucosa demonstrates the most striking peculiarity of these animal phyla. Instead of the usual transitional type which is found in mammals, the mucosa is composed of columnar epithelium, a formation which is continued throughout the renal pelvis. The muscularis is made up of interlacing bundles of more or less distinct outer circular and inner longitudinal fibers. Here and there connective tissue filaments are interspersed among the myogenic elements. In that portion of the muscularis which lies closest to the mucosa a generous supply of lymphocytes is peppered throughout the length of the ureter. This lymphoid tissue is even more profuse than that noted in the ureter of the dog or rabbit in a similar position.

Cloaca. The cloaca is divided into 3 bulbous vestibules by 2 transverse folds; the distal fold separates the proctodeum from the urodeum, the proximal one the urodeum from the caprodeum (Fig. 1B). The most distal out-pouching, the proctodeum, measuring 1 centimeter in diameter and 1 centimeter in length, opens at the anus. A smaller middle chamber, the urodeum, serves as the immediate outlet for the urinary and genital systems. It is roughly 1 centimeter in diameter and 8 millimeters long. The ureters open more closely to the fold which delineates the caprodeum (2 millimeters distant) than to the one which bounds the proctodeum (6 millimeters distant). The proximal receptacle of the cloaca, the caprodeum, is 1.5 centimeters in diameter and 2.5 centimeters in length. It joins the contiguous intestine, being the first part of the cloaca to receive the intestinal excreta.

Upon microscopic section, the cloaca is found to resemble the large intestine of mammals, being composed of mucosa, submucosa, muscularis, and serosa (Fig. 3). The muscularis is subdivided into a circular inner

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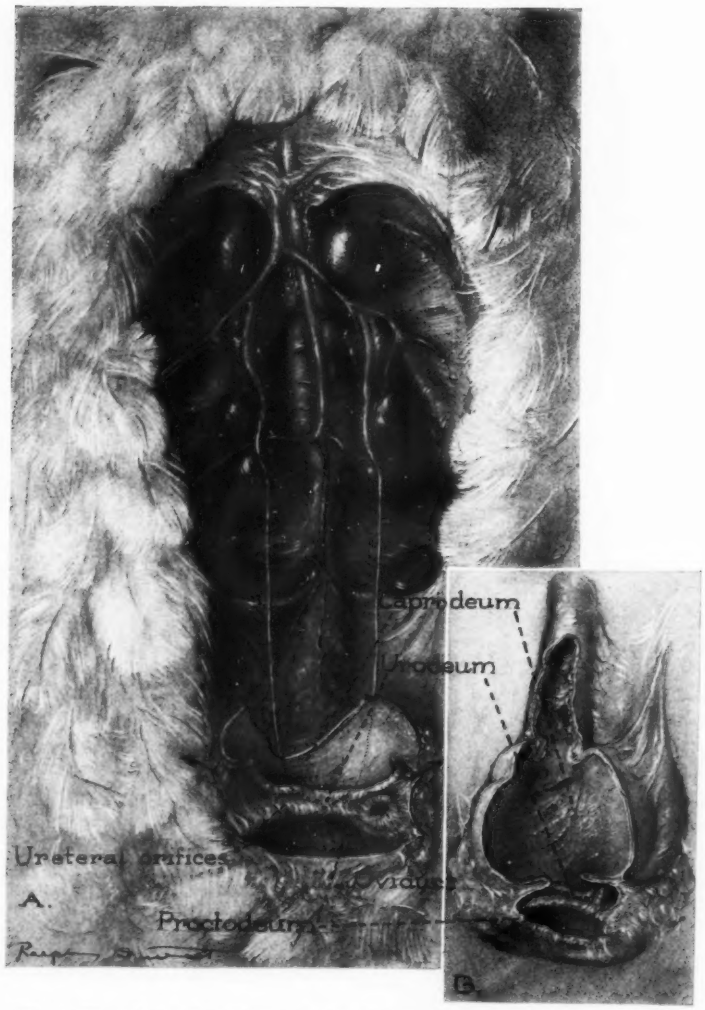

Fig. 1. The urinary cloacal tract in the chicken. Inset shows the 3 vestibules of the cloaca.

layer which is the more substantial and a thinner, outer longitudinal layer. The usual type of columnar epithelium forms the mucosa which is bordered by a vascular submucosa. There is a profusion of lymphoid follicles in both the mucosa and submucosa.

Ureterocloacal entrance. Serial sections of the ureterocloacal entrance show the ureter

MEASUREMENTS OF INTRAMURAL URETER

Specimen number	1	2	3	4	5	Average
Length in mm. of muscular channel	10.0	8.2	2.6	4.0	4.0	5.76
Length in mm. of submucosal course	1.4	1.1	1.8	0.9	1.2	1.28
Diameter in mm. of orifice	0.4	0.5	0.3	0.5	1.0	0.54

Fig. 2. Upper portion of chicken's ureter. Note the columnar type of mucosal epithelium, the inner longitudinal and outer circular fibers of the muscularis and the abundance of lymphocytes in the region of the mucosa. ×55.

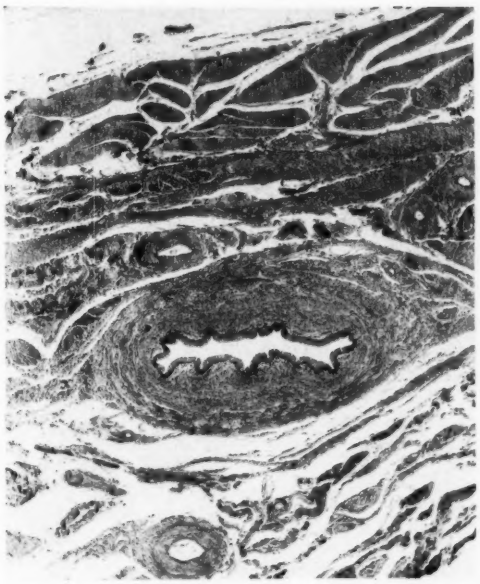

Fig. 3. Chicken's ureter immediately proximal to its entry into the wall of the cloaca. Note the inner circular and outer longitudinal layers of the cloacal musculature. ×30.

first outside the muscularis of the cloaca (Fig. 3), next transpiercing the muscularis (Fig. 4), and finally coursing submucosally (Fig. 5), to merge with the mucosa of the cloaca at the ureteral orifice (Fig. 6). The ureter progresses for an average distance of 5.76 millimeters through the muscularis and 1.28 millimeters beneath the mucosa before opening at the orifice which is 0.54 millimeter in diameter.

It will be seen that there is a complete independence of the muscular walls of the ureter and cloaca, extensive search having failed to reveal any interchange between the two systems. The muscularis of the cloaca gives way to allow penetration of the muscularis of the ureter which extends down to the ureteral orifice where it lies in direct contact with the mucosa of the cloaca (Fig. 6). Neither gross nor microscopic examination yielded any evidence of a valvular structure which might exert a rôle in closing off the ureter from the cloaca.

The anatomical features of the ureterocloacal entrance may be summarized as follows:

1. There is a complete independence and lack of union between the ureter and the intestinal musculature. The ureteral musculature persists in all its entirety to the orifice where it ends abruptly without any evidence of a transmural fading out.

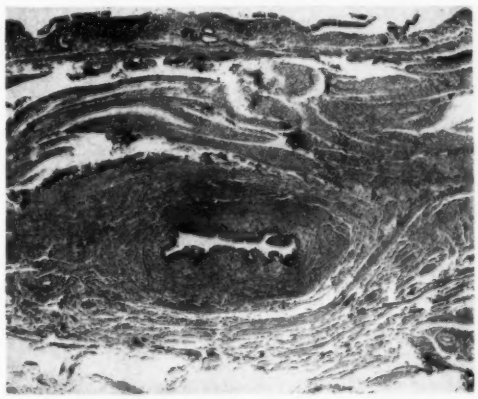

Fig. 4. The chicken's ureter transpiercing the muscularis of the cloaca. Note the circular muscle fibers coursing around the ureter. ×23.

Fig. 5. The submucosal course of the chicken's ureter ×30.

Fig. 6. The ureterocloacal orifice in the chicken. Note the muscularis of the ureter extending down to the orifice and the abundance of lymphoid tissue in the adjacent cloacal mucosa. ×30.

2. A columnar type of epithelium is found lining the ureter and renal pelvis as contrasted with the transitional type found in man.

3. The mucosa and submucosa of the cloaca are supplied with a great abundance of lymphoid tissue; lesser amounts are seen in that part of the muscularis of the ureter which borders upon the mucosa.

4. The structural arrangement at the ureterocloacal entrance gives no indication of acting as a valve.

RESULTS OF STUDY

Investigation of the ureterocloacal entrance in animals which normally possess such an anatomical arrangement, demonstrates a complete independence between the muscular layers of the ureter and those of the cloaca. The ureteral musculature transpierces the muscle layers of the cloaca, extends submucosally, and terminates only at the ureterocloacal orifice. There is no gradual thinning out or interchange of fibers similar to the fusion of the ureteral and vesical musculature of the human ureterovesical communication. Thus the two systems retain a relationship as totally independent as if the ureter were artificially implanted. Furthermore, there is no evidence of a sphincter or any type of valve formation. It is evident that a perfect result attending a submucosal type of ureterointestinal anastomosis reproduces exactly the anatomical relationship of the normal ureterocloacal entrance. Although improvements must still be sought to assure a consistently satisfactory result after operation, these findings lend encouragement to the belief that the problem is not a hopeless one.

The present study might lead one to suspect that the abundance of lymphoid tissue in the ureter and cloaca, or perhaps the columnar type of ureteral epithelium, plays a protective rôle in guarding the avian urinary tract against infection. The possibility of such a specialized resistance of tissue or of a natural immunity to the cloacal flora will be dismissed in a subsequent communication.[1]

[1] Weyrauch, Henry M., Jr., and Hinman, Frank. An experimental study of uretero-intestinal implantation. III. The significance of ureterocloacal reimplantation in the chicken. (To be published.)

ETIOLOGICAL FACTORS IN VARICOSE VEINS OF THE LOWER EXTREMITIES

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THE seeming simplicity of the injection treatment of varicose veins has evoked in the past decade a multiplicity of articles. Many of these limit discussion to the merits of favorite sclerosing agents, various bandages, and the usual assortment of pastes and promises of manufacturers; a few articles devote space to etiology. Methods of treatment have changed with increasing experience but as yet there is no generally accepted standard as to what constitutes the most adequate or satisfactory treatment, if there be such a thing. Saphenous ligation is lauded by some and condemned by others. A high percentage of recurrence is reported by many writers. That this confusion has arisen from an incomplete understanding of the cause is apparent to anyone familiar with the literature.

That proper evaluation of the hydrostatic factors in the venous system of the legs might adequately explain the frequency of varicosities at this site has been considered for many years, but numerous stumbling blocks have been encountered. Notable among the early investigators was Trendelenburg, who recognized the presence of reverse flow in varicose veins and described the test still widely used as a method for determining venous valvular incompetence. Later Delbet suggested that varicose veins might be the result of successive weakening of the valves of the saphenous system by back pressure resulting directly from increases in intra-abdominal pressure. This pressure he measured by a direct method, and venous pressures as high as 260 millimeters of mercury were recorded in the leg. Through minor inaccuracies in some of his reasoning and major inaccuracies in the reasoning of some of his critics, this work of Delbet, though widely quoted and of first importance, has never been properly appreciated, due apparently to some misconceptions. Murphy and Mengert, through their studies on intra-abdominal pressures, have added considerable support recently to Delbet's thesis. Using a balloon in the vagina they found intra-abdominal pressures as high as 200 millimeters of mercury when the patient strained. It remains to apply these latest studies to the present problem.

Several investigators anastomosed the femoral artery and saphenous vein in dogs but produced no appreciable varicosities. These studies suggested that pressure is not an important factor. Although arteriovenous anastomoses do not lead to varicosities in experimental animals, the fact remains that in humans arteriovenous fistula in the leg leads to marked varicosities in the course of a few months. This apparent inconsistency must be explained.

DeTakats et al, reported direct readings of venous pressure in the saphenous vein using a cannula and water manometer. They did not state at what point the needle was introduced into the saphenous vein, but took pressures with the patient standing, before and after saphenous ligation, and concluded that ligation produced no lasting effect inasmuch as the pressure 2 weeks after ligation was the same as it had been before. McPheeters, in his studies on hydrostatic pressures at various levels of the saphenous vein, demonstrated the effect of position, stepping, grunting (increased intra-abdominal pressure), and respiration on these pressures. His results indicate definitely the direct relationship of fluid level to pressures at various points in the saphenous system, pressure increasing toward the ankle as one might expect. He did not point out, however, that this was a pure gravity effect.

The difficulty in establishing the hydrostatic pressure factor as the fundamental cause of varicose veins has apparently been the fact

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Fig. 1. Photograph in case of arteriovenous fistula about 18 months after inception. Gunshot wound visible in thigh at arrow. Note the marked dilatation of superficial venous system and pigmentation of lower leg.

that varicose veins frequently exist in the lower leg with no evidence of saphenous incompetence as judged by existing methods of examination, and marked varicosities may be present in segments of vein limited by competent valves. At first sight this appears as a logical objection and has led many investigators to discredit the back pressure theory. If the numerous discrepancies are to be explained, it is necessary to determine, first, normal venous pressures in the lower extremity and, then, what factors may effect these pressures.

In approaching this problem we have used direct venous pressure determinations in the saphenous vein. The apparatus used is simple and consists of a piece of rubber tubing about 25 centimeters long, in the middle of which is introduced a 5 cubic centimeter glass trap. One end is connected to a Tycos manometer. This was chosen because of its small size and the fact that it registers pressure changes more rapidly than a mercury type manometer, thereby largely eliminating the inertia factor. An adapter which fits a Luer needle is inserted into the other end of the tubing, and, after testing the joints for leakage, a 15 to 17 gauge needle is connected to the adapter and inserted directly into the lumen of the vein. The

Fig. 2. Case 1, showing varicosities before and after ligation and injection. The thrombosed veins below the right knee will recede more with time.

Fig. 2

glass trap prevents the reflux of blood into the manometer. The apparatus registers changes in pressure rapidly and its sensitivity is demonstrated by the fact that the respiratory effect is readily observed, though this amounts to only 8 or 10 millimeters variation in the chest cavity itself.

The venous pressure was recorded with the patient in the prone, sitting, and standing position. The results in 9 patients are shown in Table I. It was apparent that with the patient prone, the manometer reading was zero if the slight effect of intra-abdominal and intrathoracic pressures in this position be eliminated, and this reading was not included in Table I as it is not significant. The effect of posture is immediately reflected in the manometer reading when the patient stands. We now find that the venous pressure corresponds closely to the measured height of the column of blood above our cannula point. It is this determination in which we are primarily interested.

For example: In Case 1 in the accompanying table, the actual measured standing pressure at the mid calf was 88 millimeters of mercury. By measuring the distance from our cannula point to the approximate level of the

Fig. 3. Photograph demonstrating the results of water hammer effect on the saphenous vein above the sentinal valve. The dilatations in the foss ovalis simulate femoral hernias.

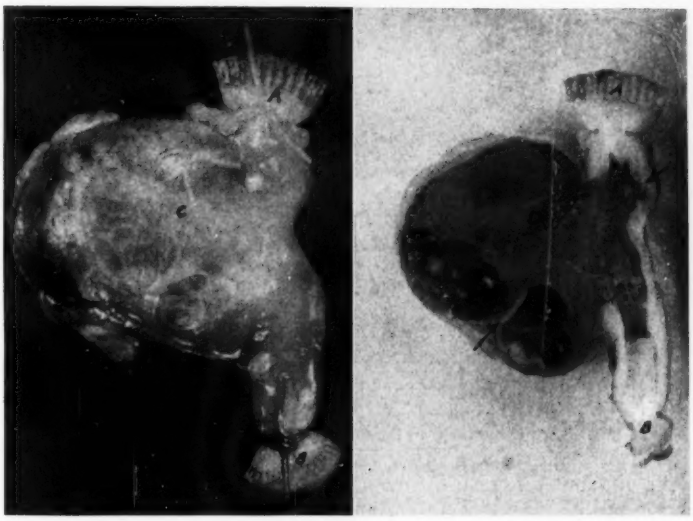

Fig. 4. Specimen removed from right groin of patient pictured in Figure 3. The photograph on the left shows the large thin walled varix (C) before opening, the superior end of the saphenous vein where it joined the femoral vein at *A*, the inferior end at *B*. On the right the varix has been sectioned after fixation so as to expose the leaflets (see arrows) of the incompetent saphenous valve and the premortem clot *D*. The darker areas are merely vacuoles resulting from fixation.

Fig. 4

Fig. 5. So called congenital angioma in a 16 year old boy involving both legs. The arterial communications in this patient must be very small as the blood pressure change, increased pulse rate, cardiac hypertrophy, and other findings of large arteriovenous fistulas were lacking. This case demonstrates very well the communications between the greater and lesser saphenous systems.

right auricle we found that this was apparently a pure gravity effect inasmuch as reducing our column of blood to millimeters of mercury gave us a figure very close to our actual reading. Because of minor inaccuracies in measurements and other factors affecting our manometer reading, some variation is expected. These do not seem sufficient to alter our conclusion.

The significant thing about these comparisons is that they hold whether the saphenous system be competent by accepted tests or not, and whether it be varicose or normal. We have studied a sufficient number of patients to make us feel that we are correct in this point. We have not included all of our cases in Table I, but have attempted to include exemplary types. The interposition of flexible

membranes (venous valves) in a fluid system does not interfere with the transmission of pressures, provided the system fulfills the requirements of Pascal's law that it be full of fluid. This must, therefore, be true in the venous system of the leg.

The effect of increasing intra-abdominal tension on our manometer is also well illustrated in Case 1. The subject was able to produce a pressure of 224 millimeters of mercury by straining in the standing position. This, in our experience, is unusually high. However, the subject was a young man of muscular build with incompetent saphenous valves. If the right auricle is considered as a sump or overflow chamber, we explain the foregoing observation as follows: As the intra-abdominal pressure is increased a point is reached where the vena cava and iliac vessels are compressed. We are then dealing with a closed system of fluid which obeys Pascal's law, i.e., pressure applied to an enclosed fluid is transmitted equally in all directions and acts with equal force on equal surfaces.

It is, therefore, logical that the height of manometer pressure will depend on the patient's ability to increase his intra-abdominal pressure. This explains the variations in pressure following straining as illustrated in Table I. Some patients, because of relaxed abdominal walls such as occur in women following pregnancy, or, because of inability to co-ordinate these particular muscular actions, are able to increase the saphenous pressure only 30 or 40 millimeters, even though the valves be incompetent.

It is quite probable that numerous acts which we have not tested raise this pressure to much greater heights than we are able to record under the conditions mentioned. It is not difficult to obliterate the peripheral arterial pulse by holding one's breath and tightening the abdominal muscles so as to increase intra-abdominal and intrathoracic pressure to above the systolic blood pressure. We have recorded pressures in the lower saphenous vein much higher than the systolic blood pressure for that individual. It must be remembered that our manometer records the sum of the gravity effect plus the added straining effect.

TABLE I.—PRESSURE READINGS TAKEN BEFORE AND AFTER LIGATION

Case	Height of auricle above cannula, cm.	Actual standing pressure, mm. Hg.	Calculated gravity effect, mm. Hg.	Manometer reading on straining, in mm. Hg.	Manometer reading on straining, post-ligation	Type of case
1. J.H.S., ♂	111	88	86.8	224	114	Valves incompetent; saphenous thrill
2. H.C., ♂	93	68	72.6	162	72	Valves incompetent; saphenous thrill
3. J.F., ♂	89	68	69.0	148	84	Valves incompetent; saphenous thrill
4. E.J.R., ♀	98	76	77.3	140	118 92	Valves incompetent; saphenous thrill
5. G.T., ♀	85	64	66.4	104	76	Varicose veins limited to lower leg; negative Trendelenburg test
6. T.D., ♀	111	81	86.8	136	92	Valves incompetent; positive Trendelenburg test
7. M.C., ♂	84	64	65.6	98	78	See photograph and specimen
8. W.W., ♂	114	88	89.0	136		Incompetent
9. J.G., ♀	95	70	74.5	102	78	Competent; varicose veins limited to lower leg

This table shows the effect of increasing intra-abdominal pressure. The actual standing pressure (column 2) as indicated on the manometer corresponds closely to the calculated standing pressure shown in column 3. The standing pressure after ligation is not shown in this table inasmuch as ligation produced no change in this reading. Because of spontaneous thrombosis of the saphenous following simple ligation, the post-ligation pressure is missing in Case No. 8.

The saphenous system, exposed as it is without the supporting effect lent by the muscles to the deep femoral system, finds itself particularly vulnerable to these pressures. It is this constantly high gravity pressure in the erect position which leads to the rapid development of varicosities in the lower extremity when the water hammer effect of the arterial pulse acts on these veins in arteriovenous fistula. In experimental animals these pressures cannot be duplicated because the overflow sump is too close to the level of the fistula and a sufficient head of fluid does not exist. This

fact was recently confirmed by Emile Holman, who reported a venous pressure of only 37 centimeters (approximately 25 millimeters of mercury) of citrate solution in the immediate vicinity of a larger femoral fistula in a dog although the systolic blood pressure was 170 millimeters of mercury. The effect of valves on pressure is of interest. We have altered some of our ideas materially in this regard. Whereas the interposition of flexible membranes in a fluid system does not interfere with the transmission of gravity effect, it was noted in the course of these studies that competent valves modified straining pressures materially. In Case 1 where the saphenous valves were obviously incompetent, the patient was able to create a pressure of 224 millimeters of mercury with one sudden strain; while in other instances, where demonstrable incompetence was not present, sustained effort was required to bring the manometer to its maximum reading, and this was never as high in the competent cases studied as in the incompetent ones. Our explanation of this difference is as follows:

The saphenous system is an elastic one. It reacts to increases in pressure by a stretching process which enlarges the vein capacity so that equilibrium between the venous pressure and the tension of the vein wall is preserved. This presupposes that sufficient additional blood is supplied during this process to keep the system full. While the valves are competent, there is some filling occurring from below as a result of the squeezing out of capillaries and smaller venous channels by muscular action and the *vis a tergo* from the arterial side. Our figures tend to show that this filling is limited in degree. Valves then dissipate to a varying degree the effect of increased intra-abdominal pressures on the saphenous system by preventing back flow. If the increased intra-abdominal pressure be maintained sufficiently long, some filling occurs from below and pressure gradually rises. If valvular incompetence is present in the saphenous system, back flow from the iliacs and vena cava constantly fills the system as the stretching process occurs, and equilibrium is not reached until the full effect of intra-abdominal pressure has been produced. The most vulnerable part of the system is effected first whether or not competent valves are present above the particular segment involved. The lower leg is usually involved early because of the higher pressure due to additional gravity effect and the more superficial nature and less adequate mesodermal support in this portion of the saphenous system.

It seems that in man the same factors which operate to produce varicosities so rapidly in the presence of arteriovenous fistula in the leg operate more slowly but in a similar manner to produce varicosities in the absence of fistula. The same head of blood is present in both instances while the pulsing surge (water hammer effect) of the fistula is mimicked by each sudden increase in intra-abdominal pressure in the simple varix. We have, in fact, noted in varicose veins with competent valves higher venous pressures than occur in arteriovenous fistulas.

We are not able to evaluate quantitatively that biological variation in our mesodermal structures which renders one individual more susceptible to these pressures than another. We do not question that this is an important predisposing factor. Patients with varicose veins frequently show other manifestations of so called mesodermal asthenia. Flat feet is such a common accompaniment of varicose veins that it has been considered an etiological factor by some writers. It would seem more reasonable to consider it just another manifestation of mesodermal weakness. We are probably not all constructed with the same grade of venous tubing, as these same gravity pressures exist in all of us but only a few develop varicosities. Straining pressures, however, are variable, and occupation, pregnancy, tumors, chronic bronchitis, etc., immediately assume a direct etiological relationship that is logical inasmuch as they effect these pressures.

The question, whether the stretching process is the result or the cause of valvular incompetence, obviously arises. We have been impressed by the frequent visible enlargement of the saphenous bulb in the oval window and by the marked pulsation and dilatation which occurs here in some cases on coughing or other efforts which increase intra-abdominal pressure. Although we did not measure this water

hammer effect, simple palpation was sufficient to indicate that it was considerable. We submit the following explanation: The result of repeated shocks is a combination of 2 factors; the valve leaflets stretch, as does the wall of the vein, and incompetence and dilatation is the result. Until incompetence results the vein below the valve nullifies a portion of this water hammer effect by dilatation, but as valves give way (Delbet) the full water hammer effect is felt by the segment of vein immediately distal to it.

We have felt that the Trendelenburg test, as usually performed, is not a satisfactory test of valvular competence, inasmuch as it takes into consideration standing pressures only. We have frequently observed patients whose valves were competent to standing pressures and so exhibited a negative Trendelenburg, yet whose valves were incompetent to the added pressure of straining and promptly exhibited a positive Trendelenburg when this factor was introduced. Consequently, we speak of a valve as being relatively competent when it withstands ordinary pressures but permits reverse flow under the added effect of strain.

If the fingers of the palpating hand of the examiner be placed over the saphenous opening of the patient in the standing position, back flow in the incompetent cases is readily detected as a palpable venous thrill when the patient coughs or strains. This test takes into consideration the factor of strain as does the modification of the Trendelenburg which we have suggested. It is simple of execution. We have seen no reference to its use in the literature.

THE EFFECT OF SAPHENOUS LIGATION ON STRAINING PRESSURES

We became interested in the effect of saphenous ligation on pressure readings inasmuch as it has been an extremely controversial point in treatment. Prior to the almost routine use of saphenous ligation we had noted the frequency of recannulization of apparently well thrombosed veins and had confirmed this finding by the examination of segments of the saphenous at varying intervals following sclerosis by injection. Large blood sinuses frequently reform in 6 weeks or less, a fact which has been observed by others. We can from our experience confirm the observation of other investigators that the varicose state frequently progresses rapidly after injection treatment. Recently Edwards reported his studies on the effect of thrombosis on venous valves. He demonstrated that recannulization of the thrombosed vein frequently occurs but that the valves are permanently disabled by adhesion or actual absorption, and the recannulized vein is always incompetent. This is significant because if recannulization does occur following treatment, we are dealing with a vein whose valves have been permanently disabled by our efforts, and rapid progression of the condition may be expected.

Following high saphenous ligation we find that standing pressures are identical with those before ligation although we have apparently severed our fluid column and should, therefore, observe a decided pressure drop. It was this observation that indirectly led de Takats to conclude that ligation did not produce the desired effect and has led to its abandonment by some. If, however, we keep in mind that friction is only a factor in moving liquids and that reducing the size of a lumen does not alter transmission of pressure, it becomes reasonable to believe that the effective column of blood remains the same, the pressure being transmitted through the communicating system of veins connecting the saphenous with the deep femoral vein, and, therefore, we could not reasonably expect any diminution in pressure. However, the significant alteration in pressure following ligation occurs when the patient strains. Now we find that the pressure rises only slightly above the standing figure and then shows no further increase regardless of the intensity of the strain. So we observe in Case 1 that after ligation the standing pressure was 114 millimeters as compared with 224 millimeters prior to ligation. The femoral vein in this patient did not transmit the increased intra-abdominal pressure to the saphenous vein through its communicating system because of competent valves, a fact which could be demonstrated before ligation (simple Trendelenburg positive). In view of the foregoing it is our belief that the squeezing out process which occurs during strain ade-

quately accounts for the small rise noted. It is also probable that muscular action collapses the femoral vein so that intra-abdominal increases in pressure are not transmitted through it. This interpretation is borne out by the majority of cases examined. We have not observed any cases of varicosities involving the short saphenous vein in which a definite communication with the long saphenous was not present, and we are of the opinion that this rather than the deep femoral vein is the usual mode of transmission of pressure to the short saphenous system.

Case 4 offers a well defined exception. Here it was noted before ligation that a large tortuous vein penetrated the deep fascia at about the lower end of Hunter's canal where a definite opening in the fascia could be palpated. Backflow filling through the deep femoral was easily demonstrated at this point. High ligation was performed as usual, but the straining pressure dropped only 22 millimeters (Table I). Following exposure and ligation of this communicating vein a further drop to 92 millimeters occurred. We have observed several cases of this type. They do not, in our experience, form a very large percentage of the total. Apparently this communicating vein transmits pressure in some cases and not in others. We believe that this may be explained. Not infrequently the course of the deep femoral vein is quite superficial in the thigh due to variations in its muscular covering until it dips down through the adductor canal where its course becomes much deeper and more subject to the compressing effect of muscular action. When an incompetent communicating vein is present it is usually just above this point. The burden of proof that communicating veins below this point transmit increases in intra-abdominal pressure lies with those who would sponsor this theory. We have seen no proof in the literature and nothing to substantiate this idea in our experience. Cases in which previous deep thrombophlebitis has disabled the valves of the deep femoral vein are the only exceptions.

THE VALUE OF SAPHENOUS LIGATION

The following hypothesis seems logical. With a patient standing so that the saphenous system is distended with blood any increase in pressure exerted on any portion of this system is transmitted equally throughout the system. This is modified by the presence of an overflow sump which is the right side of the heart, and so the standing pressure is the gravity effect of the column of blood above it. The head of blood peculiar to man because of his erect posture is a most important factor in the causation of varicose veins. It is this factor that is responsible for the rapid development of varicosities in arteriovenous fistula of the leg in man, a situation which cannot be reproduced in four-footed animals because the overflow sump is practically on the same level as the fistula. Increased intra-abdominal pressure interrupts by compression the column of blood in its intra-abdominal course, and our sump is disconnected. We are then dealing with a closed system which obeys Pascal's law. Pressure, and not the reversal of flow, is the dilating factor. Reversal of flow does, however, permit constant filling of an elastic system so that the full effects of intra-abdominal increases in pressure may be transmitted according to Pascal's law. Man, again, because of co-ordinated muscular acts peculiar to him because of his erect posture, is subject to unusual increases in intra-abdominal pressures. The deep femoral vein is not usually involved because of the protecting mechanism of muscle and fascia.

The earlier appearance of varicose veins in the lower leg seems logically explained by the additional gravity effect toward the foot, coupled with the fact that the supporting tissue is less adequate than in the thigh. It must be remembered that the decrease in the caliber of the vein does not interfere with the transmission of pressure, but only the volume of flow.

High saphenous ligation would seem indicated in all cases of varicose veins where the upper saphenous shows any dilatation or transmits the impulse of coughing or other increases in intra-abdominal pressure as detected by simple palpation, the usual contraindications to ligation to be observed of course. It should definitely help to prevent progression of the condition in a patient who has already shown evidence of vulnerability.

Cramping and fatigability so often complained of is frequently relieved by ligation alone. It is not a panacea sufficient of itself but is a very important part of our armamentarium, and the simplicity of the procedure permits its more general application. Injection without ligation where reverse flow is present is definitely contra-indicated by experience and further substantiated by Edwards' recent studies on the effects of thrombosis on venous valves. The technique of high saphenous ligation has been well detailed by numerous authors and will not be repeated here. Retrograde injection, although not utilized in the cases described in this article because of its obvious interference with pressure readings after ligation, is used in this clinic almost routinely at the time of ligation. The detailed treatment of complications, merits of various sclerosing agents, and other factors is not properly within the scope of this paper. Much of it yet remains to be unravelled. Milk leg even of minor degree, the irreversible tissue changes of lymphatic block resulting from long standing stasis or inflammation, are problems which still largely defeat us. It would seem, however, that enough is known of the simple uncomplicated type of varicose veins regardless of degree to standardize their treatment more logically. We have sectioned saphenous veins as late as 2 years after ligation and sclerosis and found no demonstrable venous channels present. We have sectioned saphenous veins as soon as 6 weeks after apparently satisfactory chemical sclerosis and found large recannulized venous channels. At present the evidence appears to support the contention of those who favor saphenous ligation.

CONCLUSIONS

1. The erect posture has resulted in venous pressure in the legs which may reach 100 millimeters of mercury, depending on height of the patient, a fact borne out by direct readings of venous pressure. This is a pure gravity effect.

2. The erect posture has developed activity stresses which markedly increase intra-abdominal pressure and indirectly raise the saphenous pressure to unusual heights not fully evaluated previously. This, combined with a vulnerability in certain individuals, probably is sufficient to produce varicose veins.

3. Venous pressures taken before and after ligation suggest that the pressure factor outside of pure gravity effect can be relieved largely by proper saphenous ligation.

4. Recannulization in incompetent veins may be expected unless preliminary ligation has been carried out. It is unlikely to occur if ligation has obviated the increased pressure effect of strain and the reverse flow in the saphenous vein.

5. We do not believe that varicosities of the lesser saphenous occur except as a result of pressures transmitted through communications with the large saphenous.

6. Modification of present methods of testing will reveal incompetence of valves that are competent to simple gravity effects, but not to increased pressures developed under strain. Such a test is described. No previous reference to its use has been noted.

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A STUDY OF PATHOLOGICALLY VERIFIED EPIDERMOID CARCINOMA OF THE SKIN

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CARCINOMA of the skin is not infrequently regarded as a relatively benign lesion, offering no particular diagnostic or therapeutic difficulties, and attended by an insignificant mortality. Study and follow-up of biopsy cases clearly bring out the danger of this assumption. It is true that epidermoid carcinoma[1], basal cell carcinoma, and malignant melanoma each present typical individual characteristics. Yet even the most experienced observer may err in the differentiation of various types of malignancy or even in distinguishing between malignant and non-malignant lesions. The practice of treating small lesions and sometimes even large ones without microscopic verification of a clinical diagnosis, leads inevitably to diagnostic errors. Thus a "typical epidermoid carcinoma" may later prove to be a malignant melanoma, or a "pigmented papilloma" turn out to be a basal cell carcinoma. Conversely, it is hardly to be doubted that "cures" have been recorded for supposed "malignancies" which were actually benign. Appropriate therapy is dependent on accuracy of diagnosis; in tumors of the skin consistently accurate diagnoses are not possible without microscopic control. A lack of appreciation of this fact has contributed to unwarranted optimism in regard to cutaneous cancer. Biopsy followed by immediate therapy does not impair the prognosis; nor even with a delay of several days in preparing sections of minute biopsies unsuitable for frozen section does the hypothetical increased danger of spread outweigh the gain in information.

It is the purpose of this paper to evaluate factors influencing one type of cutaneous malignancy: epidermoid carcinoma. It will be shown that it still offers a serious therapeutic problem, and that any lesion of this type is an active threat to life.

From the Laboratory of Pathology, Collis P. Huntington Memorial Hospital.

[1]Also known as squamous cell, prickle cell, or keratinizing carcinoma, or acanthoma.

MATERIAL USED FOR STUDY

This study is based on a consecutive series of 507 pathologically verified epidermoid carcinomas of the skin seen at the Collis P. Huntington Memorial Hospital between its opening in 1912 and January 1, 1937. The series represents lesions on 486 persons, since 19 individuals had 2 or 3 tumors each, making a total of 40 duplications. All regions of the skin have been included except lip, vulva, penis, and anus, where the mucocutaneous junctions and the frequency of mucosal cancers make it impossible to be sure of the point of origin of the tumor. Sections of all tumors diagnosed as epidermoid carcinoma of the skin in the hospital laboratory files were reviewed and regraded. Doubtful cases as well as those unsuited for histological grading (i.e., either too small or too poorly prepared) were excluded. The lesions were placed in one of three grades by the method in use in this laboratory, a modification of Broders' classification based on differentiation of the tumor cells, frequency of mitosis, and extent of infiltration. The 507 carcinomas showed the following grade distribution: 382, 75 per cent, low malignancy, grade I; 114, 22 per cent, medium malignancy, grade II; 11, 3 per cent, high malignancy, grade III. For the purpose of this study the tumors of medium and high malignancy are grouped together as grade II plus III and contrasted with the grade I lesions of low malignancy.

A follow-up of a year or longer, or a definite knowledge of the cause of death is available on all but 43 of the 507 lesions. The data were based on hospital visits as given in the record, questionnaires, and death certificates.

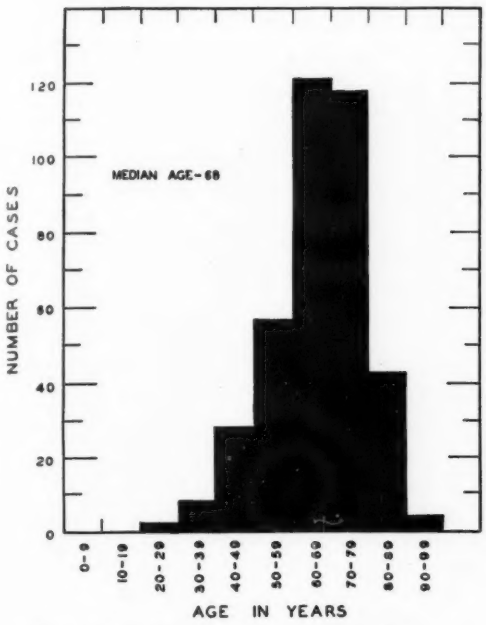

Fig. 1. a, Grade I. Age distribution by grade.

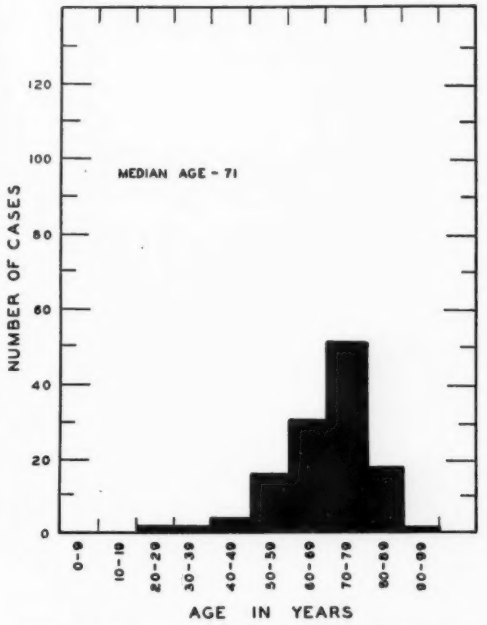

Fig. 1. b, Grade II plus III. Age distribution by grade.

We have based consideration of prognosis on those 401 cases seen and treated prior to January 1, 1933, permitting a 5 year follow-up. In this group the end-results were 158 5 year cures; 101 deaths from intercurrent disease before 5 years elapsed; 83 deaths from cutaneous cancer; 59, 15 per cent, lost (followed for less than 5 years). The case histories have been conservatively interpreted; the most pessimistic viewpoint possible concerning the result of any given lesion has been adopted, so that when a study of the available data indicated a possibility of persistence, recurrence or metastasis, this possibility has been taken as fact.

In cases of death the data were ambiguous in 6 instances. In each of these death was from cancer, but there was a possibility that another lesion—epidermoid or otherwise—might be responsible. These 6 cases have been included with the other deaths from cutaneous cancer.

One hundred and forty-five, 30 per cent, of the 486 persons represented in the series had malignancies elsewhere in the body; about 70 per cent of these were confined to the skin (Table I). Forty-six, 9 per cent, of the patients gave a history of carcinoma in some other member of the family.

AGE, SEX, AND OCCUPATION

The ages at the time of first treatment are given in Figure I. There is no significant difference in the two histological groups. The

TABLE I.[1]—MULTIPLE MALIGNANT TUMORS GROUPED BY LOCATION: SKIN OR ELSEWHERE

	Total persons	All multiples		Multiple in skin only		Multiple in skin and cancer elsewhere		Not multiple in skin but cancer elsewhere	
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Grade I	366	115	32	79	22	9	2	27	7
Grade II plus III	123	33	27	24	19	3	2	6	5
All grades	486*	145*	30	100*	21	12	2	33	7

*Discrepancies in totals from three cross-duplications between grades I and II plus III.
[1]All cases corrected for duplication; lip included with skin in this table.

TABLE II.—FACTORS AFFECTING SIZE

Size in cm.	All cases	Duration—when known				Previous treatment		Visibility	
		Less than 1 year	1 to 3 years	3 to 5 years	5 years or longer	All types	Radiation only	Visible lesions	Concealed lesions
Grade I									
1 or less	122	64	33	7	7	15	8	110	12
1.1 to 2.5	137	63	37	15	17	38	23	125	12
2.6 to 5	69	18	19	9	23	21	11	55	14
5.1 or more	36	3	9	7	15	20	13	25	11
Total	364	148	98	38	62	94	55	315	49
Approximate median size, cm.	1.7	1.3	1.7	2.2	3.3	2.3	2.3	1.6	2.6
Grade II plus III									
1 or less	15	5	4	1	4	3	3	11	4
1.1 to 2.5	57	15	25	5	10	16	8	51	6
2.6 to 5	33	9	12	4	8	15	8	29	4
5.1 or more	18	2	7	3	5	12	9	14	4
Total	123	31	48	13	27	46	28	105	18
Approximate median size, cm.	2.2	2.1	2.2	2.9	2.4	3.2	3.5	2.2	2.3

youngest patients in the series were two 20 year old males, one with a grade I lesion of the ear, the other with a grade II lesion of the arm. The oldest patient was a 94 year old male with a grade I lesion of the ear. The age span for females ranged from 29 to 90 years. More than 75 per cent of the lesions in this series occurred on persons over 60 years of age. A cross analysis of age distribution by grade, size of lesion, and location does not yield any striking relationships. Nose and eyelid, however, have a larger proportion of younger persons than any other locations: roughly a third of the cancers of the nose and a half of those of the eyelid occurred in patients below 60 years. The age distribution and the median age showed no significant sex difference; for grade I lesions the approximate median age was 68 and for grade II plus III, 71 years.

Three hundred and sixty-nine, 73 per cent, of the lesions were on males; 138, 27 per cent, on females, and this ratio of approximately 3 to 1 holds for both grades I and II plus III considered separately.

Occupational data were available on 304 males with head and hand lesions, and on 94 females. One hundred and sixty-five, 54 per cent, of the males had "outdoor" occupations (farmer, laborer, carpenter, teamster, etc.); an additional 9 with hand lesions had an occupation in which chemical or mechanical irritation might be a factor (welder, roofer, photographer, dye maker, etc.). On the contrary, none of the females had definite outdoor occupations, and only one, a laundress, had a possible irritative etiology for her hand lesion on an occupational basis. Outdoor occupation may be a partial explanation of the higher incidence in males.

SIZE

Lesions have been grouped by size based on their greatest diameter when first seen in the Huntington Hospital.

Table II gives the size distribution by grade. The longer the stated duration of the lesion, the larger the median size. The more malignant lesions are larger on the average, the median size for grade I being $1.7 \pm$ centimeters, and that for grade II plus III $2.2 \pm$ centimeters. This may be partly explained by the more rapid growth of the more malignant lesions, although the longer average duration of grade II plus III lesions must also be considered. In either event, the greater average size of the grade II plus III lesions is a con-

tributing factor to the higher mortality of this group.

Lesions which had received previous treatment before coming to the hospital averaged larger than untreated ones, but a part of this may be attributed to their greater average duration.

The visibility of the lesion correlates likewise with size; sites concealed by clothing when grouped together, contributed a disproportionate number of the larger lesions.

The largest lesions in the series were on the scalp. One grade I carcinoma 30 centimeters in greatest diameter had never healed following earlier excision, and ultimately proved fatal. A 20 centimeter grade I carcinoma of scalp was excised in July of 1926, and patient was alive and well without disease in April of 1938.

No significant relationship exists between the size of the tumor and the age of the patient.

LOCATION AND GRADE

The sites of predilection are the exposed portions of the body—the head, hands, and fingers—which account for 457, 90 per cent, of all the lesions. Table III gives the relative frequency in the various sites analyzed by grade and sex. The ears, 26 per cent, lead in frequency all locations as we have subdivided them. Hand and fingers together account for about 20 per cent. All of these cases occurred on the dorsum, none on the palm.

The ratio of low to high malignancy is approximately 3 to 1 in the various sites, the most notable exceptions being the eyelid, nose, scalp, trunk, and mastoid region, where grade II plus III lesions are proportionately less frequent. This is counterbalanced by lesions of the forehead, temple, cheek, and malar region, where grade II plus III carcinomas are relatively more numerous.

In several sites the lesions show a predilection for one sex. On the ears, mastoid region, and neck more than 90 per cent of the lesions are on males. Females have more lesions than males on scalp, eyelid, and trunk. Lesions of temple, forehead, leg, and thigh are divided about equally between males and females. The sex ratio in any one location is roughly the same for grades I and II plus III.

TABLE III.—RELATIVE FREQUENCY OF GRADES IN VARIOUS SITES BY SEX

Location		Grade I		Grade II plus III		Total by Sex	Totals	Sites per cent
		No.	Per cent	No.	Per cent			
Scalp	M	1	50	1	50	2	8	1.6
	F	6	100	—	—	6		
Forehead	M	8	61	5	39	13	24	4.7
	F	7	64	4	36	11		
Temple	M	8	61	5	39	13	25	4.9
	F	9	75	3	25	12		
Malar region	M	9	75	3	25	12	17	3.3
	F	1	20	4	80	5		
Eyelid	M	8	89	1	11	9	21	4.1
	F	12	100	—	—	12		
Cheek	M	36	71	15	29	51	73	14.4
	F	14	64	8	36	22		
Nose	M	21	81	5	19	26	42	8.3
	F	14	87	2	13	16		
Chin	M	3	75	1	25	4	6	1.2
	F	1	50	1	50	2		
Ear	M	92	77	28	23	120	130	25.7
	F	7	70	3	30	10		
Mastoid region	M	10	91	1	9	11	11	2.2
	F	—	—	—	—	—		
Neck	M	9	60	6	40	15	17	3.3
	F	1	50	1	50	2		
Trunk	M	4	100	—	—	4	11	2.2
	F	5	71	2	29	7		
Finger	M	8	100	—	—	8	17	3.3
	F	6	67	3	33	9		
Hand	M	53	80	13	20	66	83	16.4
	F	14	82	3	18	17		
Arm	M	1	33	2	67	3	5	1.0
	F	2	100	—	—	2		
Foot	M	3	100	—	—	3	3	0.6
	F	—	—	—	—	—		
Leg and thigh	M	4	80	1	20	5	10	2.0
	F	2	40	3	60	5		
Scrotum	M	3	75	1	25	4	4	0.8
	F	—	—	—	—	—		
Totals	M	281	76	88	24	369	507	100.0
	F	101	73	37	27	138		
		382	75	125	25	507		

RECURRENCE

A lesion was considered to be recurrent only if complete healing was noted to have taken place after the original treatment. There were 32 recurrences in grade I lesions and 9 in grade II plus III. Twenty-five recurrent grade I lesions and 8 of the higher malignancy group had sufficiently detailed data to warrant further analysis, approximately 7 per cent and 6 per cent, respectively (Table IV). Of these, 14 of the grade I and 6 of the grade II plus III

TABLE IV.—EFFECT OF SIZE AND GRADE OF PRIMARY LESION UPON RECURRENCE, METASTASIS, AND PROGNOSIS

Size in cm.	All cases						Cases prior to January 1, 1933					
	Number of cases		Recurrence—per cent		Metastases—per cent		Number of cases		5 Year cure—per cent		Mortality—per cent	
	I	II plus III	I	II plus III	I	II plus III	I	II plus III	I	II plus III	I	II plus III
1 or less	122	15	3	13	2	0	98	13	59	54	8	0
1.1 to 2.5	137	57	7	9	8	14	103	42	49	29	19	21
2.6 to 5	69	33	12	3	15	24	58	25	29	12	48	76
5.1 or more	36	18	11	0	22	44	29	15	10	0	73	100
Doubtful size	18	2	(Figured into the totals)				16	2	(Figured into the totals)			
All sizes	382	125	7	6	9	21	304	97	44	24	27	51

recurrences were pathologically verified. Increased anaplasia appeared only in 3 grade I lesions. In 2 instances a report on the original lesion is not available and so the recurrences as grade II or grade III might actually represent an increase in grade. Thirty-eight per cent of the grade II plus III lesions had received previous treatment, whereas only 26 per cent of grade I lesions were previously treated. This difference may be interpreted in one of two ways: either that the treated grade II plus III lesions were all originally grade II or grade III at the time when they first received treatment, and were correspondingly difficult to eradicate, or that some of them were originally grade I and recurred as grade II or grade III by the time they arrived at the Huntington Hospital.

TABLE V.—TIME OF APPEARANCE OF RECURRENCES AND LATER REGIONAL METASTASES DATED FROM ORIGINAL TREATMENT

(Appearance within time indicated)	Recurrences	Metastases
Elapsed time—Grade I—		
6 months	9	9
1 year	8	7
1½ years	1	0
2 years	2	2
2½ years	1	1
3 years	0	1
3½ years	1	0
4 years	0	0
4½ years	1	0
5 years	0	1
5½ years	0	0
6 years	0	0
6½ years	1	0
7 years	0	0
7½ years	0	0
8 years	1	0
Total	25	21
Elapsed time—Grade II plus III—		
6 months	1	8
1 year	3	2
1½ years	4	1
2 years	0	0
Total	8	11

Grade II plus III recurrences all took place within 1½ years from the time of healing after the original treatment; however, 4 grade I lesions recurred after a 3 year latent period. One of these grade I recurrences (proved by biopsy) appeared more than 6 years after the original treatment, and another (definite clinically but not proved pathologically) appeared more than 7 years after complete healing following treatment (Table V).

Subanalyses of factors affecting recurrence must be interpreted very cautiously because of the small total number of recurrences comprising the series. However, the recurrence rate in grade I was higher in the larger lesions —11 per cent for those larger than 2.5 centimeters, 5 per cent for those 2.5 centimeters or less. Not even tentative conclusions are permissible in the 8 grade II plus III cases.

In correlating frequency of recurrence with treatment of the original lesions at the Huntington Hospital it was found that there were more recurrences following radium therapy than surgical excision: 11 per cent as opposed to 6 per cent in grade I cancers and 10 per cent as against 5 per cent in grade II plus III cancers. Eight of the 58 tumors, 14 per cent, in grade I having previous radiation developed recurrences and 5 of 29 tumors, 17 per cent, of grade II plus III, which are slight increases over the average for the grade. There are not

TABLE VI.—COMPARISON[1] OF RADIUM AND EXCISION: INITIAL HEALING AND PROGNOSIS

Grade I

Size in cm.	Number of cases		Initial healing—%		5 year cure—%		Mortality rate—%	
	Excision	Radium	Excision	Radium	Excision	Radium	Excision	Radium
1 or less	87	11	99	82	61	45	4	38
1.1 to 2.5	84	13	99	82	55	8	13	67
2.6 to 5	37	15	86	27	41	0	38	67
5.1 or more	12	11	70	30	25	0	55	88
Doubtful size	12	3	—	—	—	—	—	—
All sizes	232	53	95	50	53	11	16	62

Grade II plus III

1 or less	13	0	100	No. cases	54	No. cases	0	No. cases
1.1 to 2.5	32	6	97	67	31	17	8	75
2.6 to 5	17	7	59	33	6	29	80	67
5.1 or more	8	6	50	0	0	0	100	100
Doubtful size	2	0	—	—	—	—	—	—
All sizes	72	19	82	33	26	16	38	81

[1]Cases prior to January 1, 1933.

enough lesions treated by roentgen-ray for valid comparison. Analysis by location shows nose, temple, trunk, and leg having recurrence rates more than double the group average for the combined grades.

Ulceration of the initial lesion was the almost universal rule: 24 of 25 grade I and 6 of grade II plus III. Repeated recurrences took place in about half of the cases. If metastases were present at the time of treatment, local recurrences followed in 5 of 21 cases, 24 per cent, for the entire group.

Age does not appear to be a factor.

END-RESULTS

Recent therapeutic advances cannot be appraised, since only cases in which lesions were treated prior to January 1, 1933, are used in studying end-results. Prior to 1933 the chief modes of treatment in this series were radium (used as radon) and some form of excision (either with scalpel or cautery knife). In the 25 year period covered by this report, the technique of radium therapy has varied, as well as indications for its use. The usual procedure throughout has been the surface application of nearly unfiltered radon. This often resulted in superficial regression of the tumor with continued growth in its deeper portion. Prior to 1920 the dosages were entirely inadequate in the light of present standards. At present this form of treatment is used only for superficial lesions. The diminishing use of radium in sizable tumors is shown by the following figures: 40 per cent of our verified cases were treated with radium between 1912 and 1922, 12 per cent in 1923 through 1927, and 8 per cent in the years 1928 through 1932. When radiation is deemed advisable for deeper tumors, roentgen-ray therapy, because of more uniform distribution of the rays, is now employed. No general statement as to dosage over this period of years (1912–1933) can be made because of shifting standards of treatment, and the occasional use of supplementary interstitial radiation with glass or gold radon seeds. Unfortunately the extensive employment of roentgen radiation has been a recent development and there were not a sufficient number of biopsied cases to permit inclusion in this study.

The series obviously includes all lesions excised, and only a small portion of those treated by radium since many radium treated lesions were never subjected to biopsy. Comparison between the two is permissible, however, after correcting for size and grade. The results are shown in Table VI where excision is seen to give a higher percentage of initial healing as well as a better prognosis in both histological

TABLE VII.—VARIOUS FACTORS AFFECTING PROGNOSIS, ANALYZED BY SIZE AND GRADE[1]

Grade I

Size	A—Mortality rate (per cent)								B—5 year cure (per cent)							
	Entire group	Prior radiation	All prior treatment	Recurrence	Metastases*	Entire group excluding metastases	Excluding ear and hand lesions: Excision	Excluding ear and hand lesions: Radium	Entire group	Prior radiation	All prior treatment	Recurrence	Metastases*	Entire group excluding metastases	Excluding ear and hand lesions: Excision	Excluding ear and hand lesions: Radium
Total cases (number)	304	50	82	20	34	271	104	44	304	50	82	20	34	271	104	44
1 cm. or less—%	8	50	20	25	100	3	6	38	59	29	54	25	0	61	66	45
1.1 to 2.5 cm.—%	19	40	33	100	82	6	25	67	49	45	52	0	9	53	30	11
2.6 to 5 cm.—%	48	71	57	50	90	36	50	67	29	20	22	29	0	35	30	0
5.1 cm. or more—%	73	100	100	100	75	69	57	83	10	0	0	0	0	13	30	0
All sizes—%	27	56	48	62	85	16	24	59	44	28	34	15	3	49	45	14

Grade II plus III

Total cases (number)	97	24	36	6	26	75	42	15	97	24	36	6	26	75	42	15
1 cm. or less—%	0	0	0	0	—	0	0	—	54	100	100	100	—	54	83	—
1.1 to 2.5 cm.—%	21	0	0	50	83	7	0	67	29	29	36	0	13	30	42	20
2.6 to 5 cm.—%	76	100	100	100	100	56	83	60	12	0	0	0	0	18	0	33
5.1 cm. or more—%	100	100	100	—	86	100	75	100	0	0	0	—	13	0	14	0
All sizes—%	51	67	69	40	86	31	33	75	24	21	19	33	12	28	33	20

[1]Cases prior to January 1, 1933.
*All cases with metastases up to January 1, 1937 used, since end-result known in all. Mortality rates not 100% in several grade I size groups; although there was only one 5 year cure, several patients died *uncured* of another cause. See formula for mortality.

groups and for practically all sized lesions. (In passing, it might be pointed out that the table illustrates the wide discrepancy between percentage of initial healing and true end-results when the latter are calculated conservatively. We feel that initial healing used by itself as an indication of the results of treatment is misleading and of less significance than is frequently attached to it.) Since nearly all ear and hand cases have been treated by excision, and since it might be argued that these locations carry a lower mortality and thus balance the scales in favor of excision, a comparison is made in Table VII, excluding these sites; this again shows better results following excision. An additional fact not brought out in the table is that 10 radium failures in both histological groups were converted to 5 year cures by excision, whereas only 1 excision failure was thus successfully treated by radium.

One hundred and forty-five of the individual lesions received some kind of treatment before coming to the Huntington Hospital, and 87 of these had had some form of radiation therapy. This does not include the numerous patients who treated their lesions with salves, ointments, and other simple measures of no therapeutic significance. Table VII shows the adverse effect of previous therapy on prognosis.

Table VIII demonstrates that, although the prognosis for the entire group treated 1928–1932 is better than that of the two earlier periods, this is in large part a result of the greater proportion of small lesions being treated. The approximate median size of grade I lesions in the 1912–1922 group was 2.3 centimeters; in the 1928–1932 group it was 1.3 centimeters. For grade II plus III lesions the difference is less pronounced; it was 2.4 centimeters in 1912–1922, and 2.2 centimeters in 1928–1932. Under these circumstances, the prognosis would improve for the later group regardless of improvement in therapy. Figure 2 gives the mortality rates by grades and size for these periods.

TABLE VIII.—PROGNOSIS ANALYZED BY TIME PERIODS: I, 1912 through 1922; II, 1923 through 1927; III, 1928 through 1932

Grade I

Size in cm.	1912–1922			1923–1927			1928–1932		
	Total	5 year cure—per cent	Mortality—per cent	Total	5 year cure—per cent	Mortality—per cent	Total	5 year cure—per cent	Mortality—per cent
1 or less	14	50	0	20	61	11	58	60	8
1.1 to 2.5	29	48	21	27	52	18	47	47	19
2.6 to 5	21	19	67	19	32	38	18	39	27
5.1 or more	12	0	100	9	33	50	8	0	50
Doubtful	8	—	—	5	—	—	3	—	—
All sizes	84	35	44	86	48	25	134	48	16
Median size	2.3 cm.			1.9 cm.			1.3 cm.		

Grade II plus III

1 or less	2	50	0	2	50	0	9	56	0
1.1 to 2.5	12	25	43	9	11	25	21	38	0
2.6 to 5	6	0	100	4	25	50	15	13	70
5.1 or more	6	0	100	2	0	100	7	0	100
Doubtful	1	—	—	0	—	—	1	—	—
All sizes	27	15	70	17	18	38	53	30	43
Median size	2.4 cm.			2.1 cm.			2.2 cm.		

There were 38 grade I metastases and 28 grade II plus III. In interpreting end-results, 34 grade I metastases, 9 per cent, and 26 grade II plus III, 20 per cent, were further analyzed. Twenty-five of this group of 60 were pathologically proved. The metastases were to the regional nodes in all cases except one in which regional nodes were not mentioned while "liver and lung" metastases were reported on a death certificate. In 2 of 8 cases in which patients died of the cutaneous cancer and in which postmortem material is available to us, there were also distant metastases: one, a primary tumor of the scrotum, had metastases to the para-aortic nodes; the second, a primary tumor of the lower leg, had liver metastases. In addition, 3 death certificates mentioned distant metastases: one, a carcinoma of the ear, was reported to have "liver and lung metastases"; the second, a

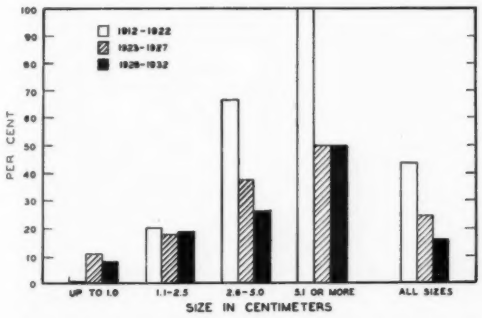

Fig. 2. a, Grade I. Mortality rate by time intervals, by size, and by grade of primary lesion.

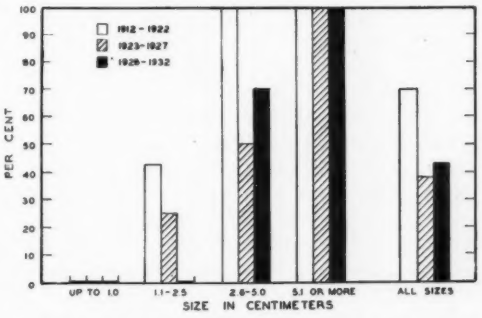

Fig. 2. b, Grade II plus III. Mortality rate by time intervals, by size, and by grade of primary lesion.

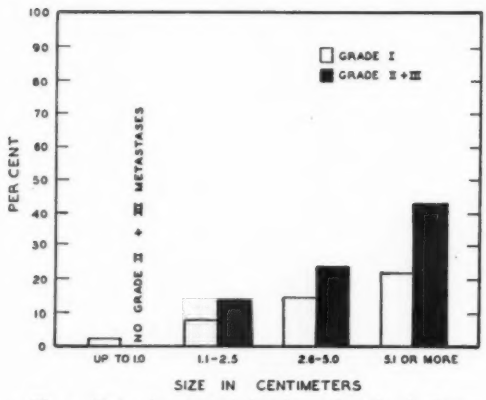

Fig. 3. Rate of metastasis by size and grade of primary lesion.

TABLE IX.—DURATION TO DEATH IN FATAL CASES, FROM TIME OF FIRST TREATMENT

(Death within time indicated)

	Grade I	Grade II plus III
Time elapsed—		
6 months	9*	1
1 year	16	13
1½ years	12	7
2 years	5	7
2½ years	3	2
3 years	0	0
4 years	4	1
5 years	3	0
6 years	2	0
7 years	3	0
8 years	0	0
9 years	1	0
Total	58	31

*Includes three postoperative deaths, and one post-x-ray death.

carcinoma of the cheek, mediastinal involvement; the third, a carcinoma of the ear, "metastases to the brain." Since in none of these 3 instances is the method of establishing the diagnosis known, they may be taken merely as interesting observations. One may conclude that distant metastases are rare.

Thirteen of the grade I lesions showed regional metastases when the patient was first seen; 21 developed them subsequently. In the higher malignancy group, 14 showed metastases on admission and 11 developed them subsequently. The time when the metastasis made its appearance is indicated in Table V. Metastases from grade II plus III lesions took place in less than 1½ years from the original treatment, whereas those from grade I occurred up to 5 years afterward.

A definite relationship between the size of the lesion when first treated and its power to metastasize is demonstrated in Figure 3 showing a jump in rate from less than 5 per cent for all lesions 1 centimeter or smaller to 22 per cent in grade I and 44 per cent in grade II plus III lesions larger than 5 centimeters. The figure also shows the increased power to metastasize in the higher grades size for size.

Approximately 18 per cent of the previously treated lesions in grade I and 32 per cent of grade II plus III metastasized—substantial increases over the group averages. Previous radiation therapy did not further increase this tendency. However, the grade II plus III cancers which had been treated previously did not metastasize more frequently than would be expected from the greater size of the lesions; the treated grade I lesions, on the other hand, when corrected for size metastasized more than half again as frequently as the untreated group.

A study of the type of treatment given the original lesion showed 5 per cent—15 of 288—of all grade I lesions treated by excision developing metastases subsequently and 7 per cent —4 of 54— of those treated with radium. In grade II plus III the figures were: excision, 11 per cent, and radium, 16 per cent.

Age distribution of the metastases differs in the two groups. In the lower malignancy group there is a higher rate of metastasis in the younger patients; in the higher grades metastases seem to be independent of age. These findings are borne out by a further analysis correcting for size. Location of the original lesion does not seem to play an important rôle except that tumors of the nose and eyelid rarely metastasize.

Ninety-five deaths were directly attributable to epidermoid carcinomas of the skin. This gives a mortality of nearly 19 per cent. An additional 18 were not cured at the time of the last follow-up, or at the time of the patient's death from other causes. Of the deaths, 62 occurred in grade I lesions, a 16 per cent mortality, and 33 in grade II plus III lesions, a 26 per cent mortality.

One of the reasons why cutaneous carcinoma sometimes fails to receive the attention it deserves is that it is so slow in killing, even when it does prove fatal. Table IX shows the time elapsing between first visit and death in the 89 cases treated at the Huntington Hospital. The deaths within 6 months include 4 dying as a result of treatment: 3 postoperative fatalities, and 1 death from erysipelas following an x-ray treatment to a carcinoma of the ear. The table not only shows the protracted course but also indicates that degree of malignancy has some bearing on the life expectancy in fatal cases.

In analyzing the deaths, one notes how unfavorable most of the fatal lesions already were when first treated. Of the 95 deaths, 6 received no treatment at all or treatment elsewhere. Twenty-one of the remaining 89 already showed metastases when first seen, and 23 that did not metastasize were larger than 5 centimeters. Thus, at least 50 of the fatal cases offered little hope of cure when first seen.

PROGNOSIS

It is especially difficult to investigate factors affecting prognosis in a group of elderly persons who have a limited life expectancy. We have applied here the "5 year cure" principle which is an accepted standard in all fields of cancer investigation; but it must be realized that the age incidence in our series is considerably older than that in any other form of cancer, and that 25 per cent die of intercurrent disease unrelated to the skin lesion within a 5 year period. Since we have adopted conservative formulas for expressing the rate of cure and mortality, it must likewise be remembered that these figures are consequently rather less favorable than they would be in equivalent groups of younger persons. However, a consideration of mortality and cure together does allow certain conclusions:

The formula that we employ for per cent 5 year cure is as follows:

$$\frac{\text{Number of 5 year cures} \times 100}{\text{Total cases treated}}$$

The formula for per cent mortality is:

$$\frac{\text{Number of deaths from cancer} \times 100}{\text{Number of 5 year cures} + \text{uncured cases (living and dead)} + \text{deaths from cancer}}$$

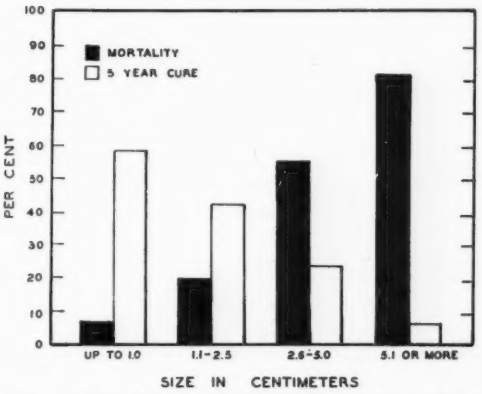

Fig. 4. Size of primary lesion and prognosis, combined grades.

Calculation by this method leaves a residual group not presented in the tables made up of cases followed less than 5 years, and cases dead of intercurrent disease before 5 years.

As previously explained, only patients on whom a 5 year follow-up was possible—those treated prior to January 1, 1933—have been used in the prognosis studies; these number 401—304 grade I and 97 grade II plus III.

Size. The relationship between the size of the lesion at the time of first treatment, and prognosis, is illustrated in Figure 4, where all other factors except size are disregarded: the larger the lesion, the poorer the outlook for cure and the greater the mortality.

Age. Age does not bear any certain relationship to prognosis. Table X indicates that the younger patients and the very old should be given a more guarded prognosis, for grade I tumors have a worse prognosis in the younger age group and grade II plus III tumors in the older, though there is no significant increase in the size of the lesion in these age groups.

Grade. One must consider that grade II plus III lesions average larger than grade I lesions, in comparing the prognosis of the two groups. Figure 5 and Table IV compare the mortality and 5 year cure after correcting for the size of the lesion. Grade II plus III lesions have a consistently less favorable outlook, more pronounced in the larger lesions.

Location. It might be supposed that tumors in certain locations would be more malignant

TABLE X.—PROGNOSIS AND AGE
Cases prior to January 1, 1933

Years	All grades			Grade I			Grade II plus III		
	Total	5 year cures—per cent	Mortality—per cent	Total	5 year cures—per cent	Mortality—per cent	Total	5 year cures—per cent	Mortality—per cent
39 or less	11	18	67	7	14	75	4	25	50
40 to 49	29	59	26	25	60	22	4	50	50
50 to 59	59	47	31	45	51	32	14	36	25
60 to 69	120	46	28	98	48	27	22	36	38
70 to 79	132	36	33	94	44	24	38	16	60
80 or more	49	18	47	34	24	27	15	7	75
All ages	400	39	32	303	44	27	97	24	51
Doubtful age	1			1					

TABLE XI.—LOCATION AND PROGNOSIS
Cases prior to January 1, 1933

		Entire group	Ear	Cheek and malar region	Forehead and temple	Nose	Eyelid	Mastoid region and neck	Hand and finger	"Cosmetic group"	"Non-cosmetic group"
Total cases		401	111	74	43	33	20	18	69	175*	156*
Mortality rate—%	Grade I	27	21	48	31	40	21	0	11	38	24
	Grade II plus III	51	64	58	60	25	—	20	33	53	50
5-year cure—%	Grade I	44	57	25	34	25	55	54	53	33	53
	Grade II plus III	24	19	23	14	40	—	80	20	21	28

*Excludes hand and foot.

than others. Table XI shows nose and face lesions to have a high mortality, while hand and finger, mastoid region, and neck carry a low mortality. Although it is found that the more favorable sites have slightly smaller lesions, correcting for size fails to explain the difference.

One may divide locations into those in which cosmetic considerations play a rôle: cheek, forehead, eyelid, temple, malar region, nose, and chin—and those in which cosmetic considerations are not of especial interest: ear, scalp, trunk, mastoid region, neck, leg, scrotum, arm, and thigh. The number of cases in the two groups is approximately the same, and the size distribution does not differ significantly. A comparison of the prognosis of these two groups, when considered by grade, is shown in Table XI. There is an improved prognosis with the group in which cosmetic considerations do not influence therapy.

The graver prognosis when the lesion had received previous radiation therapy has already been pointed out (Table VII). This accords well with the prognosis of recurrences, since a good many lesions receiving prior treatment were probably recurrences rather than out-and-out therapeutic failures at the time of their first visit here. Table VII shows that the outlook after recurrence has taken place is also graver—the 5 year cure rate in grade I is 15 per cent; the mortality rate, 62 per cent. There are too few cases for significance in grade II plus III although they show the same trend.

The treatment of metastases has been most discouraging (Table VII). Of 34 grade I metastases, there was only one 5 year cure which followed a dissection of axillary metastases from a lesion on the dorsum of the hand. There were 29 deaths, and 4 uncured at the time of the last follow-up. In grade II plus III metastases there were three 5 year cures in the 26 cases, all following excision of the affected nodes. Two of the primary lesions were of the leg with groin metastases, and 1

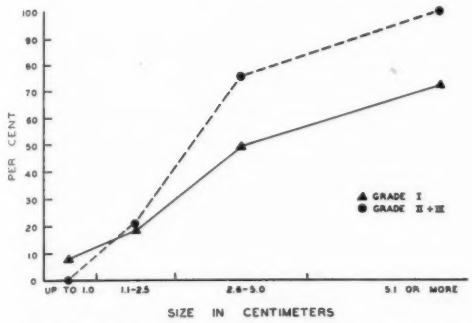

Fig. 5. a, Mortality rate. Grade and prognosis, corrected for size.

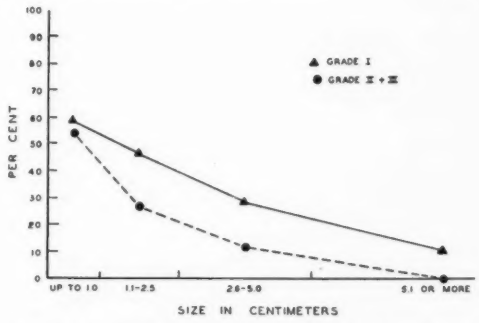

Fig. 5. b, Percentage of 5 year cures. Grade and prognosis, corrected for size.

was of the ear with cervical metastases. There were 19 deaths, and 4 patients were followed for less than 5 years.

Since it has been shown that the increased power to metastasize is one of the characteristics of the more malignant lesions, and since it can be seen that metastases markedly increase the mortality, the question naturally arises as to whether the increased mortality rate in grade II plus III is a result solely of the metastases. However, when all metastasizing lesions have been excluded, the grade II plus III lesions still carry the graver prognosis (Table VII) in sizes larger than 2.5 centimeters.

SUMMARY

1. Five hundred seven consecutive cases of pathologically verified and graded epidermoid carcinoma of the skin on 486 persons, seen at the Collis P. Huntington Memorial Hospital in the 25 year period ending December 31, 1936, are reviewed statistically. Three hundred and eighty-two, 75 per cent, were grade I, 114, 22 per cent, were grade II, and 11, 3 per cent, were grade III.

2. Ninety-five of the lesions were known to result fatally, a mortality of 19 per cent. The size of the lesion when first treated is shown to influence prognosis more than any other factor; lesions larger than 5 centimeters carried an 82 per cent mortality as contrasted with a 7 per cent mortality for those 1 centimeter or smaller. Histological malignancy is next in importance, grade II plus III lesions carrying a 5 to 20 per cent greater mortality than the less malignant grade I lesions for any given size larger than 1 centimeter.

3. Other factors affecting prognosis adversely are treatment prior to coming to the hospital (especially with radium or x-ray), and the presence of metastases at the time of admission. Duration of the lesion or its location in unexposed sites are of importance only in so far as they affect the size.

4. Analysis of therapeutic results indicates that radium (used only as radon and largely as surface radiation) is less satisfactory than surgical excision. In recent years radium therapy has been increasingly restricted to the more superficial lesions. Too few proved cases which were treated by the roentgen-ray are represented in this series to warrant comparison.

5. Analysis of prognosis by succeeding time intervals shows an improvement in outlook in the most recent one (1928–1932 inclusive). This is explained in large part by the greater proportion of small lesions in the latest time period rather than by fundamental improvements in therapeutic technique. It suggests that the best prospect for control of cancer of the skin, as with cancer elsewhere, lies in early recognition and adequate treatment while the lesion is still small.

STUDIES ON THE CHEMICAL STERILIZATION OF SURGICAL INSTRUMENTS

I. A Bacteriological Evaluation

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THE disinfection of sharp implements by immersion in a chemical solution has gradually become an established practice. According to a recent survey by Ecker and Smith, 36 per cent of the hospitals reported the use of such a procedure. A similar institutional census (1) would indicate that for the sterilization of scalpels 63 per cent use chemical solutions exclusively.

Because of the ease and convenience with which the chemical principle may be applied, its wide application would unquestionably be justified if such a method does, indeed, produce "complete" sterility within a reasonable length of time. Contaminated surgical instruments, however, occasionally contain bacterial spores, as well as the less resistant vegetative forms. Most of these spores are highly resistant to destruction by chemicals. The anthrax spore, for instance, is capable of surviving 5 per cent phenol for a period of from 2 to 40 days (24). Since all disinfectants operate by combining chemically with the protein or other constituents of the bacterial cell, the presence of any organic matter diminishes the germicidal activity. Therefore, surgical instruments should constitute difficult objects for disinfection, since they are often allowed to dry while covered with blood and exudate. Is it not pertinent, then, to ask whether the chemical agents recommended for this purpose have been adequately and appropriately tested?

The literature contains only meager data regarding the practical testing of chemical solutions against contaminated instruments. Leusden and von Bremen recently compared boiling alone with boiling in solutions of disinfectant, the latter being definitely superior. Ecker and Smith and Sobernheim studied the action of hot solutions of soda, formalin, and borax upon soil spores. "Cold" sterilization, however, has not been investigated in a controlled or practical manner. Most of the data upon which proprietary and non-proprietary solutions are recommended consist of phenol coefficient determinations or various modifications of the Reddish germicidal test (16). The phenol coefficient is inadequate for testing undiluted surgical disinfectants. Its applicability for other purposes is being questioned constantly (8, 11, 12), but it is especially inappropriate as an index of bacterial destruction in the presence of large amounts of blood and tissue dried upon metal.

The series of experiments to be described attempts to determine the length of time required by selected chemical solutions to sterilize knife blades heavily contaminated with pure cultures of bacteria suspended in blood or exudate. No standard procedure for the testing of surgical disinfectants has been proposed. The United States Food and Drug Administration recommends the phenol coefficient method (18). Since this technique is of dubious value, the general principle described in the present article might serve as a basis for the formulation of a standard procedure (17).

Chemical solutions tested. Many agents have been proposed for the chemical sterilization of instruments. For this study 7 solutions have been selected to represent as many different types of products as possible. Ecker and Smith found that phenol (alcohol rinse), 50 to 95 per cent alcohol, and varying concentrations of lysol were most commonly employed. In addition, 3 commercial products were chosen because of their wide usage and fundamentally different compositions. The institution at

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TABLE I.—NON-SPORULATING SPECIES
Shortest test interval (minutes) producing sterility

	Phenol-alcohol	Alcohol 70 per cent	Cresol 5 per cent	Borax-formalin	Metaphen	Bard-Parker	Zephiran	Blade count (thousands)
Staphylococcus aureus								
Pus Wet	½	2	3	10	2	½	3	11,520
Dry	3	10	10	5	5	½	3	81
Blood Wet	½	2	1	10	3	½	3	4,032
Dry	½	5	3	5	3	2	5	144
Pseudomonas pyocyanea								
Pus Wet	½	1	5	10	3	½	10*	72,000
Dry	½	1	3	10	5	½	30*	7,200
Blood Wet	½	½	5	10	2	½	30	432,000
Dry	½	2	3	5	3	1	10	5,700
Escherichia coli								
Pus Wet	½	½	½	10	½	½	2	2,340
Dry	½	1	5	10	3	½	20	2,700
Blood Wet	½	½	2	10	1	½	10	16,800
Dry	½	1	2	3	3	½	20	10,200
Streptococcus hemolyticus								
Pus Wet	½	½	½	½	½	½	1	49
Dry	1	½	½	½	½	½	½	9
Blood Wet	½	1	3	3	2	½	5	4,752
Dry	Controls negative—did not resist drying							
Monilia albicans								
Pus Wet	½	1	2	5	2	½	½	1,280
Dry	½	1	2	2	3	1	1	81
Blood Wet	½	2	½	2	3	½	2	160
Dry	½	1	2	2	2	1	3	80

*Positive at end of test period.

which these experiments were performed employs a borax-formalin mixture.

The non-proprietary disinfectants are: (1) Phenol-alcohol; a 95 per cent solution in distilled water of carbolic acid meeting the requirements of the United States Food and Drug Administration for phenol coefficient testing (18); 10 cubic centimeters of 95 per cent ethyl alcohol as a rinse. (2) A 70 per cent solution of ethyl alcohol in distilled water. (3) Five per cent cresol; compound mixture of cresols, U. S. P. in distilled water. (4) Borax-formalin; a 5 per cent solution of sodium tetraborate in 10 per cent formalin.

Proprietary solutions are the following: (1) Metaphen germicidal solution, aqueous, 1:2500. (2) Formaldehyde-alcohol; Bard-Parker formaldehyde germicide, formaldehyde 8.0 per cent, ethyl alcohol 67.8 per cent, methyl alcohol 9.3 per cent. (3) Zephiran; alkyl-dimethyl-benzyl-ammonium chloride, aqueous, 1:1000.

Bacterial species used. Eight different species were selected for study:

TABLE II.—SPORULATING BACILLI
Shortest test interval (hours) producing sterility

	Phenol-alcohol	Alcohol 70 per cent	Cresol 5 per cent	Borax-formalin	Metaphen	Bard-Parker	Zephiran	Blade count (thousands)	
								Total	Spores
Bacillus anthracis									
Pus Wet	8	18	8	1	4	¼	1	900	180
Dry	18	+	4	1	+	¼	4	900	90
Blood Wet	+	+	+	2	+	1	4	80,640	864
Dry	+	+	+	1	+	1	+	1,080	136
Clostridium tetani									
Pus Wet	+	+	+	18	+	18	18	630	28
Dry	+	+	+	18	+	18	+	540	72
Blood Wet	+	+	+	18	+	18	18	3,240	63
Dry	+	+	+	18	+	18	+	360	176
Clostridium welchii									
Pus Wet	18	+	18	4	18	1	2	360	2
Dry	+	+	+	8	+	2	8	9	1
Blood Wet	18	+	18	8	18	4	1	324	26
Dry	+	+	+	18	+	4	2	7	2

+Denotes growth after 18 hours' exposure.

Non-sporulating: (1) Staphylococcus aureus, a hemolytic strain freshly isolated from an abscess. It was positive for coagulase and fermented lactose and mannitol. By the criteria of Chapman et al. This is a definitely pathogenic type. It withstood 1:60 dilution of phenol for 5 minutes at 20 degrees C. as required in the Food and Drug Administration phenol coefficient test. (2) Escherichia coli, a hemolytic strain isolated from urine. (3) Pseudomonas pyocyanea, recently recovered from a case of otitis media. (4) Streptococcus hemolyticus, Group A (Lancefield) culture originating from acute conjunctivitis. (5) Monilia albicans, yeast-like fungus recovered from bronchial secretion of a case diagnosed as bronchomoniliasis.

Sporulating: (1) Bacillus anthracis, isolated in 1936 from a human case of anthrax. Agar plate washings from an 18 day culture in concentration of 880,000 spores per cubic centimeter withstood 100 degrees C. for 2 but not for 5 minutes. (2) Clostridium tetani, an old laboratory strain. The tetanus bacillus was chosen because its spores are unusually resistant. An 18 day agar culture in a concentration of 21 million spores per cubic centimeter survived 100 degrees C. for 20 but not for 30 minutes. (3) Clostridium welchii, recently recovered from a case of gas gangrene. An 18 day culture with 22 million spores per cubic centimeter resisted 100 degrees C. for 10 but not for 15 minutes.

Test bacterial suspensions were prepared by washing the agar cultures with 5 cubic centimeters of sterile saline solution. The exception was Clostridium welchii which was grown in a carbohydrate-free, cooked, meat medium. The non-spore-forming bacteria were used as 20 to 24 hour cultures; *Monilia albicans* was allowed to grow for 5 days. The spore-forming bacilli were tested whenever a large number of spores had developed (7 to 10 days).

TECHNICAL PROCEDURES

The ideal method for studying surgical disinfectants would employ implements obtained directly from an operative procedure. For

extensive controlled experiments, however, this is impractical. The method followed throughout the present experiments is intended to simulate as far as possible the worst surgical conditions. Detachable knife blades were immersed in mixtures of bacteria and blood or pus. Upon removal the contaminated blades were exposed to the several germicides for definite periods of time and subcultured to broth for evidence of growth. Both wet and dried blades were subjected to the test.

Preparation of blades. New No. 10 Bard-Parker detachable knife blades were first treated to remove all trace of oil.[1] They were then placed in a sterile petri plate and sterilized in the hot-air oven.

Preparation of bacteria-body fluid mixtures. One specimen of pus, sufficient for all the tests, and containing no spores, was sterilized by heating in the water bath at 56 degrees C. Before use it was centrifuged lightly to remove coarse coagula. The other body fluid consisted of sterile citrated human blood stored for 4 or 5 days in the ice-box. Four cubic centimeters of agar plate washings, free of clumps, were mixed with 6 cubic centimeters of blood or pus.

Density of bacteria-body fluid mixtures. The number of bacteria present markedly influences disinfectant activity (6). If, then, one is to duplicate a condition of extreme contamination, it is necessary to know the average and greatest number of bacteria and spores to be found in actual purulent exudate. Therefore, 21 consecutive routine specimens of pus received in the hospital laboratory were utilized for this purpose. A blade dipped in the specimen was transferred to 9 cubic centimeters of saline solution and thoroughly shaken. The total bacterial count and the number of spores present were determined by dilution plates using infusion blood agar. Duplicate aerobic and anaerobic plates were poured. The sum of both plate counts was considered the total. One specimen, consisting of extremely thick pus, contained an enormous number of bacteria, a blade count of 15 million. The average blade count was 100,000. The greatest number of spores per blade was 15, the average being 2. It is conceivable, of course, that blades which had been used upon a case of gas gangrene and permitted to dry for several hours might contain several hundred spores. Therefore, an attempt was made to use bacterial suspensions yielding blade counts which were far in excess of the figures here mentioned.

Method of performing the tests. Each blade was aseptically removed from the petri plate by hooking a bent platinum needle into the hole of the blade. After being dipped into the bacteria-blood mixture, it was carefully lowered into an 85 by 15 millimeter tube containing 5 cubic centimeters of disinfectant solution. Each blade was placed in a separate tube of germicide. Following the desired exposure the blade was removed, rinsed in a tube containing 10 cubic centimeters of broth, and transferred at once to a second tube of broth where it remained throughout the period of incubation. Rinsing was accomplished by shaking the blade vigorously in the broth for 5 seconds. This procedure was followed throughout except for the phenol series which received an additional rinse in 95 per cent alcohol, and the Zephiran blades with which 2 broth rinses were necessary to overcome bacteriostasis. Both the rinsing and the final broth tubes were incubated for evidence of growth. The length of incubation varied from 6 to 14 days at 37 degrees C. The presence of the metal blade frequently produced a turbidity and precipitate in the broth. Black sulfide was formed by the anaerobes. As a result, all the broth tubes in which growth was not grossly evident were examined microscopically for the presence of bacteria.

A duplicate set of blades was treated as above except that, upon removal from the bacteria-blood mixture, they were dried at 37 degrees C. for 6 to 8 hours. Aseptic conditions were maintained by placing the blades in a sterile petri plate containing an ordinary glass slide, in such a manner that they were supported at one end by the slide. At a different time the entire experiment was repeated, and in this experiment pus instead of blood was used as the mixture fluid. All tests were conducted at room temperature, approximately 27 degrees C.

[1] I am grateful to the Bard-Parker Company for the large number of blades necessary for this study.

Time of exposure to the disinfectants. The non-sporulating organisms were exposed for ½, 1, 2, 3, 5, and 10 minutes. In some instances it was necessary to repeat the test using longer exposure times. The spore-forming bacilli were tested after intervals of 5, 15, and 20 minutes, 1, 2, 4, 8, and 18 hours in the case of wet blades. The dried blades were not always cultured at the 5 minute or the 8 hour periods.

Media employed. The nutritive quality of the recovery medium has been shown to be of paramount importance in the testing of germicides, since an organism surviving a killing factor is more fastidious in its growth requirements (3, 13). Sabouraud's dextrose broth (Difco) was used for Monilia albicans, beef infusion broth, prepared according to Wright, for Streptococcus hemolyticus and brain-heart infusion broth (Difco) containing 0.05 per cent cysteine hydrochloride, for the anaerobic bacilli. For the remaining organisms the recovery medium consisted of Liebig's meat extract, 0.5 per cent; Difco proteose peptone, 1.0 per cent; sodium chloride, 0.5 per cent. In all instances 10 cubic centimeter volumes of broth were employed.

Anaerobic technique. The anaerobes, Clostridium tetani and Clostridium welchii, were incubated according to the method of Weiss and Spaulding. Luxuriant growth is regularly obtained in 24 hours.

Controls. The importance of, and necessity for, separating bacteriostasis from bactericidal power has been repeatedly emphasized (6, 9, 11). The bacteriostatic ability of each of the above solutions had been determined previously under the test conditions. Nevertheless, a set of control blades was included in each experiment. Sterile saline solution was substituted for the bacterial washings. Blades immersed in blood were exposed to the germicide and transferred to broth with the customary rinses. Each tube was then inoculated with 0.1 cubic centimeter of a 1:10,000 dilution of the bacteria-body fluid mixture being used.

By count it had been found that the number of bacteria inoculated to the control tubes in this manner was approximately one two-hundredths of that present on the test blades. In addition, one member of each set of dried blades was placed in salt solution, instead of germicide, and subcultured to test the ability of the organism to withstand drying. The hemolytic streptococcus, in one instance, did not survive. It has been shown by Murray and Headlee (7, 14, 15) that the drying process frequently decreases the thermal resistance of bacteria.

Experimental data. The accompanying tables present the detailed data. The figures given represent the first test period at which the corresponding tubes failed to show growth.

CORROSION TESTS

During the course of the experiments it seemed advisable to compare the corrosive action of the several chemical agents. To be satisfactory for practical usage a chemical solution must be not only germicidal but non-corrosive as well.

Ten knife blades (oil removed, but not previously used) were placed in each of 7 flasks containing 50 cubic centimeters of the respective germicides. For 5 weeks the flasks remained stoppered; during an additional 5 weeks they were allowed to remain open to the air. Storage was maintained at room temperature.

Results. The cresol, borax-formalin, and Bard-Parker formaldehyde solutions showed no evidence of corrosion after 10 weeks. Metaphen produced very slight corrosion beginning at the end of the second week, which did not progress further. Zephiran, 95 per cent phenol, and 70 per cent alcohol began to corrode after 24 hours to 2 days. With phenol and alcohol this became extreme in 2 weeks; Zephiran produced extreme corrosion by the end of the sixth week.

ANALYSIS OF STUDY

From an examination of the accompanying tables it becomes obvious that the vegetative forms of bacteria are rapidly destroyed by these chemical agents, even when they are dried in the presence of body protein. If one were dealing, therefore, only with the non-sporulating cell, the chemical sterilization of instruments might be rapidly accomplished with a high degree of safety.

Bacterial spores, however, are extremely resistant to physical and chemical factors. When one recalls that the spore of Bacillus anthracis will withstand boiling for 10 minutes, that of Clostridium welchii for 5 minutes, and the tetanus spore from 15 to 90 minutes (21), it is indeed not surprising that most of these chemical solutions do not sterilize spore-contaminated blades within 18 hours. The borax-formalin and the formaldehyde-alcohol solutions appear to be the best spore-killing agents. Only these 2 germicides destroyed all 3 types of spores regularly within 18 hours. In this connection Scott has reported the superiority of formaldehyde over phenol in sterilizing anaerobic cultures.

The data reveal striking evidence of variation among different species. The difference in susceptibility of bacterial species to a single agent has been clearly pointed out by Garrod (5). In the present experiments, for instance, Zephiran was excellent for killing Staphylococcus aureus under the test conditions, but relatively inactive against Pseudomonas pyocyanea or Escherichia coli. It is of some interest that 95 per cent phenol is a superior bactericidal agent for vegetative forms but poor as a sporicide.

No attempt has been made to study the tendency of the different solutions to leave a residue on instruments after removal from the solution, their ability to penetrate the joints or crevasses of hinged instruments, the effect of continued usage, or the liberation of irritating fumes. These factors are subjects for further investigation.

Likewise, no consideration has been given to the practice, regularly followed by those who have adopted chemical sterilization, of washing the instruments before immersion in the disinfectant. Because this desirable step is obviously subject to considerable variation, it may best be viewed as providing a wide and highly desirable margin of safety.

CONCLUSIONS

1. Four non-sporulating species of bacteria, 3 sporeformers, and a yeast-like fungus were exposed to 7 different chemical solutions widely used for the chemical sterilization of surgical instruments.

2. A practical laboratory method for testing such disinfectants in the presence of blood or pus is suggested.

3. With one exception the non-sporulating organisms failed to survive an exposure longer than 30 minutes.

4. Bacterial spores were, on the other hand, highly resistant. Four of the solutions were not effective within the time limit used. The formaldehyde-alcohol and the borax-formalin solutions appeared to be the best sporicidal agents.

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THE SIGNIFICANCE OF CEVITAMIC ACID DEFICIENCY IN SURGICAL PATIENTS

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THE motive which led to the study of the problem to be presented was created over a period of years of close observation of postoperative complications. It must be apparent to every surgeon that frequently serious postoperative complications occur which demand some sort of explanation and perhaps prevention. Of these, non-healing of wounds as expressed by evisceration, postoperative hernia, or incomplete disruption of a wound, peritonitis from a leaking suture line, and non-union of fractures take a ranking position. Secondarily one may also allude to hemorrhage, wound infection, disturbances in function, such as delayed gastro-intestinal motility, loss of appetite with increasing weakness and prostration, nausea and vomiting, respiratory infections, and the like.

In a communication during 1935 attention was called to the nutritional status of the surgical patient and two elements of malnutrition were stressed, namely, protein deficiency and avitaminosis. An interexchange of ideas with Graham, of London, finally focused our attention on cevitamic acid deficiency.

Scurvy is a disease which has been recognized for many centuries, although until quite recently its nature was a mystery. Hippocrates described it quite accurately. It is interesting to read an account of the ravages of scurvy in Lord Anson's fleet during a voyage around the world in 1740–44 as described by Richard Walter, chaplain on board the "Centurion" published in London in 1750. In writing of the disease he states:

"This disease is likewise attended with a strange dejection of the spirits, and with shiverings, tremblings and with a disposition to be seized with the most dreadful terrors on the slightest accident. Indeed, it was most remarkable, in all our reiterated experience of this malady that whatever discouraged our people, or at any time damped their hopes, never failed to add vigor to the distemper; for it usually killed those who were in the last stages of it, and confined those to their hammocks who were before capable of some kind of duty; so that it seemed as if alacrity of mind and sanguine thoughts were not contemptible preservations from its fatal malignity. It often produced putrid fevers, pleurisy, the jaundice, and violent rheumatic pains, and sometimes it occasioned an obstinate costiveness, which was generally attended by a difficulty of breathing; and this was esteemed the most deadly of all scorbutic symptoms; at other times, the whole body, and more especially the legs, were subject to ulcers of the worse kind attended with rotten bones, and such a luxuriancy of fungous flesh as yielded to no remedy. But a most extraordinary circumstance, and what would scarcely be credible upon an single evidence, is that the scars of wounds which had been for many years healed, were forced open again by this virulent distemper. Of this there was a remarkable instance of one of the invalids on board the 'Centurion' who had been wounded above fifty years before at the battle of the Boyne for though he was cured soon after, and had continued well for a great number of years past, yet, on being attacked by the scurvy, his wounds, in the progress of the disease, broke out afresh, and appeared as if they had never healed; nay what is still more astonishing, the callus of a broken bone which had been completely formed for a long time, was found to hereby dissolve and the fracture seemed as if it had never been consolidated."

This amazing report opens the door to some well chosen speculation such as the effect of excitation and fear upon cevitamic acid metabolism especially as associated with the adrenal glands, also, wound healing. Further reference may be found concerning wound healing as associated with scurvy in the *Medical and Surgical History of the War of the Rebellion* in which in describing the clinical picture of scurvy it is written:

"This was further manifested by the indisposition of wounds to heal, slight scratches becoming converted into indolent ulcers or affected with erysipelas

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or gangrenous inflammation. . . . Doctor Jones refers to the ulcerations induced among the prisoners at Andersonville by slight injuries as the prick of a splinter or the scratching of a mosquito bite."

In the *Nashville Journal of Medicine and Surgery* of 1866 Eve stated:

"It certainly did complicate wounds and seriously interfered with surgical operations and was itself aggravated by erysipelas, syphilis, spurious vaccination. Secondary hemorrhage became more frequent from wounds and operations after the battles of Chickamauga and Missionary Ridge, September and December 1863; attributable justly to the increased scorbutic tendency in the soldiers as the war progressed."

Bizarre manifestations characterize scurvy, many of which are familiar; however, at the present time fully advanced cases are comparatively rare except among the children of the extremely poor. It is the incipient stage or latent scurvy which concerns us at the present time. McLester has stated that in the guinea pig a period of time elapses between the actual exhaustion of the vitamin C reserve and the appearance of scurvy, during which time pathological changes are taking place. He further believes that the same situation obtains in man and that there is constant need of a vitamin C supply because without appearance of actual scurvy, changes similar to those in the guinea pig occur which impair resistance for intercurrent infections. Moreover, different animals respond quite characteristically to vitamin C. Hart, Steenbock, and Smith report that cattle can be reared to maturity on a diet which will produce scurvy in guinea pigs in 4 or 5 weeks, and Hess, in *Scurvy, Past and Present*, states:

"We are confronted with the remarkable and inexplicable phenomenon, a fact concurred in by almost all investigators, that a diet induces either normal nutrition or malnutrition, according to the experimental animal employed. A diet of polished rice or other decorticated grain will lead to the development of scurvy in the guinea pig, to polyneuritis in the pigeon or fowl or according to Holst and Froelich, to a combination of these in the hog. . . . The nutrition of rats, mice, rabbits, hogs, pigeons, and fowls receiving a diet identical with that which regularly occasions scurvy in guinea pigs either progresses normally or a state of malnutrition develops which cannot be identified with scurvy."

It has been demonstrated that man, the monkey, and the guinea pig cannot form vitamin C and must depend upon extraneous vitamin C for their needs while all other animals can apparently synthesize it. Therefore, it is practically impossible to produce a true vitamin C deficiency in most animals, while in man, the monkey, and the guinea pig, it is relatively common and can be induced by a low intake.

In this communication we wish to consider chiefly the relation or association of cevitamic acid deficiency with wound healing. We have considered the many vagaries of cevitamic acid metabolism, also we are conscious of the many other factors and conditions associated with the sick or injured individual.

Wound healing is effected by many intrinsic and extrinsic factors. Certainly the patient's nutritional status is one of the most important intrinsic factors. Proteins, carbohydrates, fats, water, minerals and vitamins all contribute to nutritional well-being. We immediately recognize, for instance, in many advanced gastrointestinal malignancies, cases in which all of these are partially depleted. Nevertheless, at the present time the preparation of such patients for operation consists only in the administration of fluids, carbohydrates, and salt, and then often in inadequate or poorly balanced amounts. If a transfusion is given, it is usually because of a frank anemia rather than because of a protein depletion. Rarely are any of the vitamins considered in planning the preoperative regimen. The postoperative care is seldom more complete than the pre-operative in this respect. A wound cannot be expected to heal unless the essential building materials necessary to its repair are present, and we believe that vitamin C is one of these. Therefore the object of this communication is twofold: to increase interest and knowledge of vitamin C in wound healing, and to present a method of saturating the depleted patient and to note some phenomena in the course of saturation.

Although, the history of scurvy and even some evidence of its relation to wounds is very old, the history and work that lead directly to the present recognition of the relation of vitamin C to wound healing is not so old. During the World War Aschoff and Koch noticed constant pathological changes in the

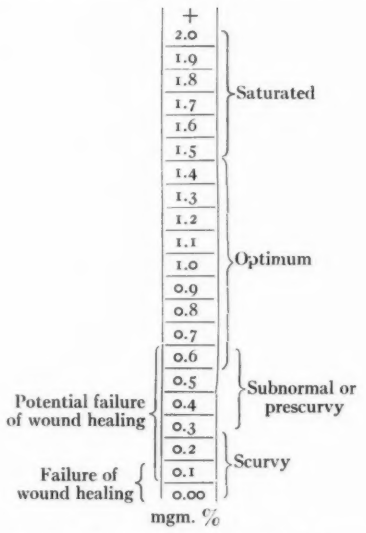

Chart 1. Significance of various blood levels.

		Mgm.			Mgm.
1.	W. Z.	−0.77	29.	E. S.	−1.12
2.	W.	−0.45	30.	B. I.	−1.38
3.	J. E.	−0.82	31.	R. M.	−1.03
4.	R. J.	−0.74	32.	D. M.	−1.60
5.	W.	−0.68	33.	A. N.	−0.69
6.	H.	−0.48	34.	R. M.	−2.29
7.	G. L.	−0.56	35.	J. S.	−0.92
8.	W. S.	−0.43	36.	R. S.	−0.80
9.	S. B.	−0.96	37.	F. S.	−0.92
10.	P. S.	−0.56	38.	E. W.	−1.49
11.	H. C.	−0.82	39.	L. W.	−1.49
12.	L. R.	−1.68	40.	E. W.	−1.15
13.	R. D.	−1.04	41.	F. G.	−0.44
14.	Z. S.	−0.48	42.	O. A.	−0.60
15.	C.	−0.80	43.	R. A.	−0.96
16.	S.	−0.22	44.	P. B.	−1.04
17.	R. Z.	−0.79	45.	J. B.	−1.16
18.	Y.	−0.62	46.	W. B.	−0.68
19.	W. M.	−0.74	47.	C. C.	−0.92
20.	M.	−0.13	48.	W. C.	−0.64
21.	C. S.	−0.97	49.	J. C.	−0.44
22.	B. J.	−0.81	50.	F. C.	−0.28
23.	R. H.	−1.35	51.	G. D.	−0.88
24.	F. B.	−0.64	52.	E. G.	−0.60
25.	D. W.	−0.68	53.	J. G.	−0.88
26.	J. M.	−0.76	54.	D. F.	−0.60
27.	P. G.	−1.32	55.	L. F.	−1.24
28.	B. H.	−2.08	56.	B. L.	−1.29

Chart 2. Blood ascorbic acid on a group of students 19–30 yrs. of age.

supporting structures of scurvy victims. Höjer in 1924 duplicated this observation in guinea pigs in which he produced scurvy experimentally. He made the further significant observation that the changes noted were largely due to a collagen deficiency. Wolbach confirmed this observation in experiments upon guinea pigs, in which he controlled the formation of collagen and reticulum around isolated fibroblasts in wounds of animals varying from totally scorbutic to those with a normal vitamin C nutrition. Logically following are the experiments of Jeney and Törö in which they demonstrated a marked increase in collagen fibrils in *in vitro* cultures of fibroblasts following the addition of cevitamic acid to the media.

Sir Reginald Payne reporting on the postmortem findings after partial gastrectomy made the statement that in 12 of 16 patients who had died from peritonitis "the peritoneal infection appeared to have arisen as a bacterial leakage at the site of anastomosis following an almost complete absence of any fibrinous response along the suture line." Archer and Graham on the basis of this report and some work they had done on patients with scurvy reasoned that many patients with gastric or duodenal ulcers were in a "subscurvy" state. Of 20 cases they checked, 90 per cent had definitely low levels and 60 per cent showed blood levels of 0.2 milligrams per cent or less.

Lanman and Ingalls and Taffel and Harvey studied groups of guinea pigs on normal and vitamin C deficient diets. All of the animals were subjected to upper abdominal and gastric incisions with suture and then sacrificed at selective postoperative intervals so that the tensile strength of the wounds might be tested. In all cases after the fifth postoperative day the normal animals showed greater wound strength. Gross examination of the ruptured wounds in the deficient animals showed changes strikingly resembling those found in non-infectious wound disruption in humans. Microscopically there was evidence of fibroblastic proliferation but marked decrease in intracellular material and a disorganized arrangement of the fibroblasts. There was also a consistent failure of the corium to unite in the deficient group.

Smith and McConkey added further similar evidence when they demonstrated that scari-

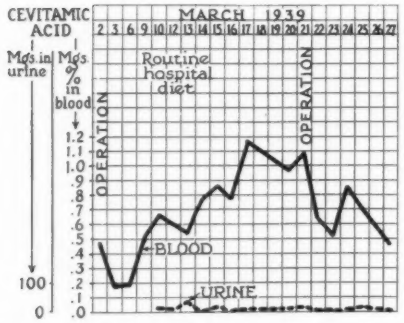

Chart 3. B. V. Male, aged 56 years. Diagnosis: carcinoma of the rectum. Bloody and watery stools for 1½ years and loss of 50 pounds of weight in past 2 years. Home diet balanced but meager. Colostomy on March 2, 1939, and closure of distal loop on March 21, 1939. He was on routine hospital diet while the cevitamic acid studies were made.

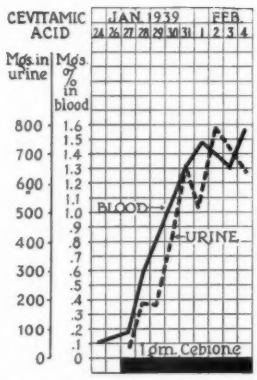

Chart 4. C. A. Male, aged 57 years. Diagnosis: peptic ulcer of the posterior gastric wall. History of pain and distress for 4 months with a weight loss of 35 pounds. Almost daily vomiting for 4 months. Restricted diet and frequent use of bicarbonate of soda to control pain. Gastric resection with anterior Pólya anastomosis on February 22, 1939. The observations and cebione administration were carried on until the patient was discharged but are not indicated in the chart because they were not of special interest. Total amount of vitamin C excreted in the stools on February 4, 1939, was 5.75 milligrams while the blood level was high, 1.575 milligrams per cent and the urinary excretion for the day was 031.35 mgs.

fied duodenal mucosa failed to heal in vitamin C deficient guinea pigs but healed promptly in the control animals. They also demonstrated a marked tendency to spontaneous formation of peptic ulcers in the deficient animals as compared with an almost negligible tendency in the control animals.

We have checked the blood ascorbic acid levels on numerous patients and have had the opportunity to follow blood, urine, and feces levels on deficient patients who have come to surgery; to saturate these patients, and then to note their wound healing. In all of the cases to be discussed the blood and urine determinations were made by titration with 2:6 dichlorophenolindophenol, the Farmer-Abt microblood technique being used for the blood determinations.

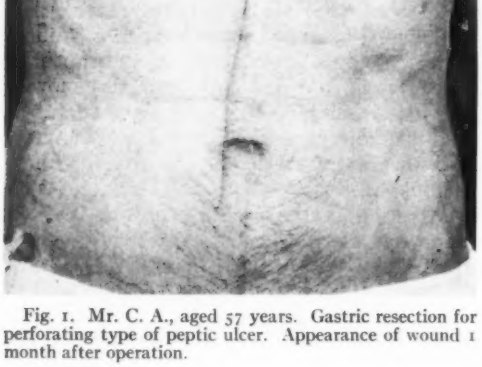

Fig. 1. Mr. C. A., aged 57 years. Gastric resection for perforating type of peptic ulcer. Appearance of wound 1 month after operation.

The usual method of saturation was to give 1 gram of cebione (Merck) daily. This was given intravenously to avoid errors in absorption as might be the case in vomiting, gastric stasis, and the like. The cebione was mixed with one-half gram of soda bicarbonate and diluted with distilled water to a volume of approximately 30 cubic centimeters *just before* administering, in order to reduce irritability in the venous system.

Our impression of the significance of the various blood levels is depicted in Chart 1. The highest figure we have found recorded on a patient with scurvy symptoms was 0.35 milligrams per cent. Therefore, this figure must delimit the scurvy from the subnormal group at least for the present. On the other hand, it is entirely possible for an individual to have a blood level considerably below this figure and not show symptoms of scurvy, the most likely explanation being that a lowered

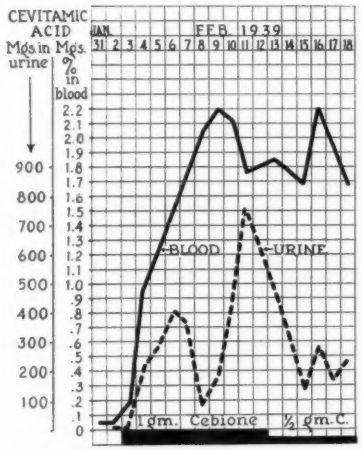

Chart 5. J. R. Male, aged 54 years. Diagnosis: extensive peptic ulcer of the lesser curvature of the stomach. The first ascorbic acid estimation was made 1 month after admittance to the hospital during which time he had extensive alkaline therapy and restricted diet. No operation was performed. He excreted 7.03 milligrams of vitamin C in his stools on February 3, 1939, at which time the blood level was 0.18 milligrams per cent and the urinary excretion for the day was 2.82 milligrams.

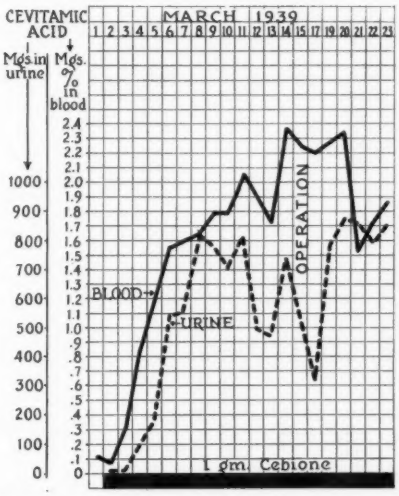

Chart 6. W. H. Male, aged 47 years. Diagnosis: colloid carcinoma of the stomach. History of abdominal discomfort for 1 year with frequent use of bicarbonate of soda Only occasional vomiting. The patient took an average amount of fruit juice and did not restrict his diet notably. Posterior gastro-enterostomy was performed on March 15 1939.

blood level is followed at a considerably later period by tissue changes.

This latter fact again is important in attempting to define an optimum level which we indicate as varying from 0.6 to 1.5 milligrams per cent. The optimum and pre-scurvy groups actually overlap more than is indicated. A vitamin C balanced person, who because of an operative procedure or infection utilizing more vitamin C, or who is deprived of a vitamin C intake for several days, may have a low blood level, but will respond quickly to an intake of orange juice or pure cevitamic acid. Conversely, a truly subnormal person given a large dose of cevitamic acid will have a sudden elevation in the blood ascorbic acid level but he cannot maintain this level unless the intake remains high while the tissues are becoming saturated.

Chart 2 illustrates the blood ascorbic acid levels on a group of students from 19 to 30 years of age. In several instances markedly low values are indicated and histories of C deficient diets were obtained. Otherwise, the list is quite representative of any group of average normal individuals upon fairly balanced diets. The several low values are of note because they illustrate the tendency to eliminate the vitamin C containing foods when under economic stress.

The following case illustrates what may be considered the average cevitamic acid levels of the ordinary surgical case and indicates that a well balanced hospital or home diet will maintain an individual.

B. V., a male clinic patient, 56 years of age, entered Passavant Memorial Hospital with a diagnosis of carcinoma of the rectum. His home diet was not restricted except as was necessarily due to a meagre family budget. His original blood level was 0.4 milligrams per cent (Chart 3) and therefore in the subnormal group as we should expect, but studying the chart we find he responded well to the vitamin C content of the average hospital diet so we feel that he did not have a tissue depletion. His urinary output of vitamin C was very low at all times illustrating that he was using most of his intake to maintain his blood and tissue levels. There is shown the typical postoperative depression in the blood level and urinary output.

Patients with gastric disease in the majority of instances use alkalies and a very restricted

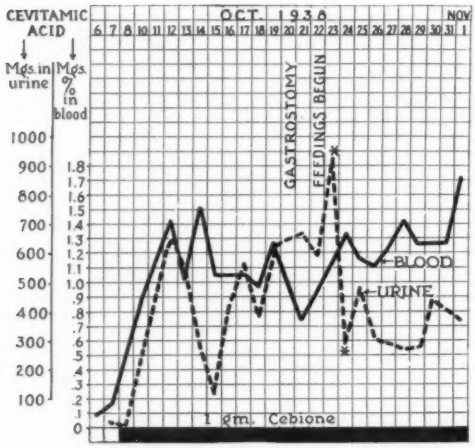

Chart 7. A. S. Male, aged 72 years. Diagnosis: carcinoma of the middle third of the esophagus. History of substernal distress after eating, dysphagia growing progressively worse, and a loss of 40 pounds in 3 months previous to entrance to the hospital. On October 10, 1938, 4.53 milligrams of vitamin C were excreted in the stools and on October 14 only 0.94 milligrams with a blood level of 1.50 milligrams per cent and a urinary excretion of 281.18 milligrams. On the 17th, 18th, and 19th of October the stools contained 1.7, 1.04 and 0.25 milligrams of vitamin C. During this time the blood levels were high and the maximum daily urinary excretion was 626.45 milligrams. Asterisk indicates error in the separation of the specimens of October 23 and 24.

Fig. 2. Mr. A. S., aged 72 years. Gastrostomy for carcinoma of the esophagus. Appearance of patient 5 months after operation. Note the tanning of chest from deep x-ray therapy, appearance of gastrostomy, and emaciation despite gain of 15 pounds in weight since operation.

diet, both because they find that they are more comfortable on that regimen and also because the use of alkalies is the basis of most peptic ulcer therapeusis. Therefore, in this type of case the blood ascorbic acid levels are low and there is often present a tissue depletion. The following case reports are illustrative:

C. A., a male clinic patient, 57 years of age, entered Passavant Memorial Hospital with a diagnosis of peptic ulcer. There was a history of epigastric pain and distress for 4 months and a weight loss of 35 pounds. His diet was voluntarily limited to very soft bland foods and he used soda bicarbonate frequently during the day. His first blood ascorbic acid levels were 0.1 and 0.13 milligrams per cent (Chart 4). He was given a gram of cebione intravenously every day and in 3 days the blood level rose to normal and he excreted a large percentage in the urine. He was operated upon because of a suspicion that carcinoma was present and approximately two-thirds of the stomach was resected and an anterior Pólya anastomosis was done. The clips were removed on the fourth postoperative day and his course while in the hospital was quite without event. The wound healed promptly (Fig. 1).

J. R., a male clinic patient, 54 years of age, entered Passavant Memorial Hospital with an extremely large lesser curvature ulcer. When first seen he had a history of having taken, on advice of a friend, a teaspoonful of mustard seeds daily for 2 weeks, as a "cure" for rheumatism. Such violent spasms of epigastric pain ensued that he had to take several teaspoonfuls of soda bicarbonate every 10 to 20 minutes for 10 days previous to admittance to the hospital. His diet had been restricted to milk, much of which he vomited. In the hospital he was placed on a bland diet and continuous Amphojel drip through a gastric Levine tube. One month later the blood ascorbic acid determination was 0.045 milligrams per cent (Chart 5). After a single dose of 1 gram of cebione the blood level rose to a normal—0.9 milligrams per cent—and remained above optimum limits during the remainder of the period of observation. The urinary output on the fourth day after cebione was started was 405 milligrams for the 24 hours. However, the urinary excretion of vitamin C again

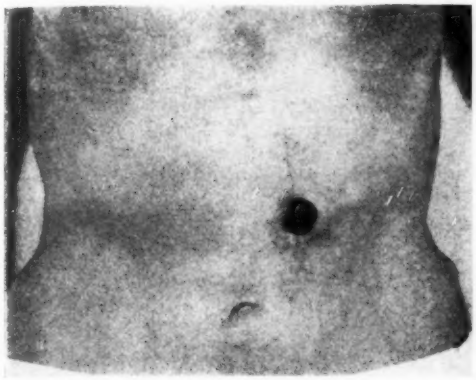

Fig. 3. Close up of wound and gastrostomy shown in Figure 2 to show character of wound healing.

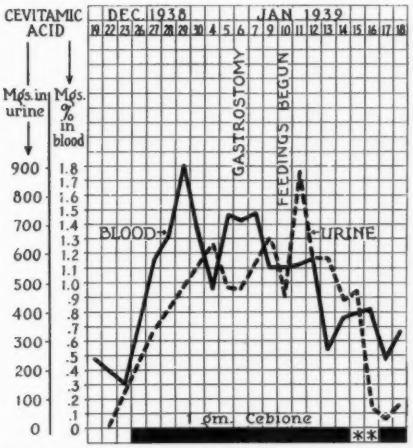

Chart 8. S. K. Male, aged 69 years. Diagnosis: advanced carcinoma of the cardiac end of the esophagus. Symptoms of esophageal obstruction for 8 weeks. Loss of 25 pounds of weight in past year. Stools on January 18, 1939, contained 0.37 milligrams vitamin C. Asterisk indicates error in computing dosage.

dropped as low as 87 milligrams per 24 hours and finally reached a normal excretory level for a daily dose of 1 gram of cebione (744 mgm. excreted per 24 hours) on the ninth day after cebione was begun. When the daily dose of cebione was cut to ½ gram daily the total excretion dropped sharply whereas the computed absorption of vitamin C and the blood ascorbic acid level remained constant.

In this case the alkaline therapy was more rigorous and as a result the original blood level was lower than in the preceding case. Also in this case is well illustrated the fallacy of taking the first high blood level to indicate saturation.

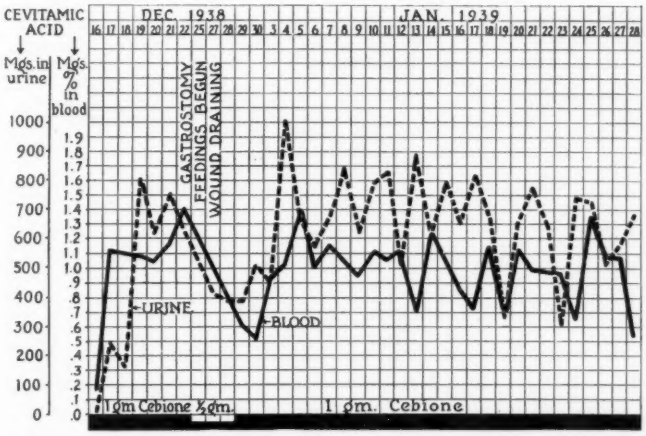

Chart 9. S. L. Male, aged 50 years. Diagnosis: carcinoma of the middle third of the esophagus. History of substernal pain, vomiting of food, and coughing for 3 months. Had deep radiation therapy over site of lesion and had had x-ray evidence of spread of the lesion into the hilus of the left lung. Estimation of amounts of vitamin C in the stools showed on December 20, 1938, 1.01 milligrams, on January 6, 1939, 1.0 milligrams and on January 23, 1939, 1.01 milligrams.

Fig. 4. Mr. L. C., aged 70 years. Jejunostomy for carcinoma of lower third of esophagus and cardia. Appearance of patient 1 month after operation.

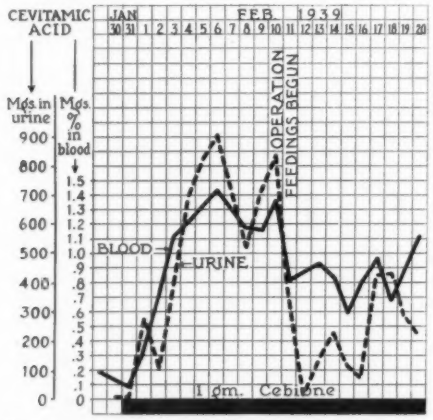

Chart 10. L. C. Male, aged 70 years. Diagnosis: carcinoma involving the cardiac end of the stomach and lower end of the esophagus. Progressive dysphagia and vomiting of 8 months' duration. Weight loss of approximately 40 pounds. Urinary retention upon admission to the hospital. Jejunostomy was done on February 10, 1939.

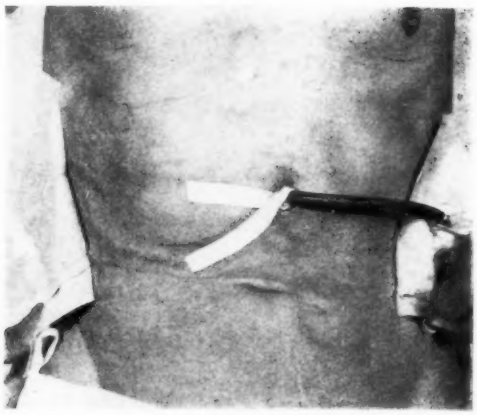

Fig. 5. Close up of wound in Figure 4 to show character of healing.

W. H., a male clinic patient, 47 years of age, entered Passavant Memorial Hospital with a diagnosis of carcinoma of the pyloric end of the stomach. He had symptoms of gastric distress for 1 year, but had vomited only on several occasions. He had not restricted his diet and on the basis of his history we had reason to believe that he had a better intake of orange juice than the first patient with carcinoma of the rectum who had a blood ascorbic acid level of 0.4 milligrams per cent. However, his original blood

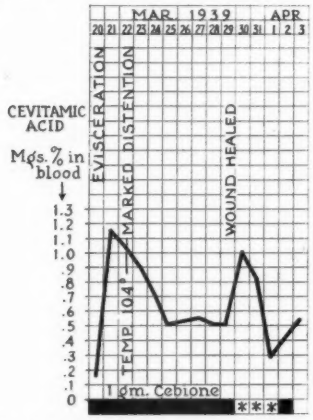

Chart 11. C. L. Female, aged 4 years. Diagnosis: exstrophy of the bladder. Implantation of ureters into the colon. Lower midline incision. Eviscerated on the sixth postoperative day. Resutured on March 20, 1939. Patient later developed intestinal obstruction and on April 18, 1939, the abdomen was again opened through a left lower rectus incision to free adhesions. Healing again occurred promptly and without event. Asterisk indicates that no cebione was given because of error.

ascorbic acid level was 0.12 milligrams per cent (Chart 6). Investigation revealed that he had taken a total of about a pound of soda bicarbonate weekly to control his pain. Two days after starting cebione the blood reached a normal level and on the seventh day the urinary output indicated a probable tissue saturation. After operation there was a slight drop in urinary excretion of ascorbic acid, probably indicating a slight increase in utilization of cevitamic acid.

In a recent communication on the subject of wound disruption and postoperative hernia, Singleton and Blocker state: "It is common knowledge that wound healing is delayed in patients showing emaciation, general debility, or old age, and this is especially noticeable in patients with cancer." They further point out that of the 160 cases of disruption they reviewed, 22 per cent were not accompanied by the local contributing factors of infection or hematoma but there was merely a nonunion of the wound margins.

The next few cases reported, therefore, should have been ideal candidates for failure of wound healing and disruption.

A. S., a male clinic patient, 72 years of age, entered Passavant Memorial Hospital with a diagnosis of carcinoma of the middle third of the esophagus. He was emaciated having lost 40 pounds in the 3 months before entering the hospital. His original blood ascorbic acid levels were 0.08 and 0.16 milligrams per cent (Chart 7).

He was prepared with cebione in the usual manner and was also given what liquids high in protein and carbohydrate that he could still swallow, supplemented by intravenous glucose and salt solution. A Spivack type gastrostomy was done through a left upper rectus incision. He wished to be up in a wheel chair the next day and was allowed to do so. Feedings were started through the gastrostomy tube on the third postoperative day, the wound edges did not separate, and no herniation or keloid formation has occurred 7 months after operation (Figs. 2 and 3).

S. K., a male clinic patient, aged 69 years, entered Passavant Memorial Hospital with a diagnosis of advanced carcinoma of the inferior end of the esophagus (Chart 8). He had symptoms of 8 weeks' duration and a loss in the past of at least 25 pounds of weight. He was similarly prepared and a Spivack gastrostomy was done. He left the hospital on the eleventh day after operation. One week later he became irrational, comatose, and died 2 weeks after being discharged.

This case is interesting because, although his general condition from the time we first saw him was that of a rapid downhill course of an advanced malignancy, his wound healed as rapidly as did that of the previous case, and the gastrostomy functioned perfectly up to the time of his death.

S. L., a male patient, aged 50, entered Passavant Memorial Hospital with an advanced carcinoma of the middle third of the esophagus. He had received radiation therapy and had early evidence of spread of the carcinoma into the mediastinum and hilus of the left lung. He was prepared in the same manner as the previous cases (Chart 9). On the third postoperative day a temperature elevation and chill indicated infection and the next day the wound was opened inferior to the gastrostomy and foul pus was evacuated. Several days later gastric secretion was evident in the wound. The patient had persistent paroxysms of coughing which became slowly but progressively worse. Despite these handicaps the infection cleaned up and the wound granulated in with remarkable rapidity. Such is entirely contrary to the usual course of gastrostomy wounds with the three complicating factors of infection, gastric secretion in the wound, and paroxysms of severe coughing.

L. C., a male clinic patient, 70 years of age, entered Passavant Memorial Hospital with a diagnosis of carcinoma of the lower end of the esophagus and cardia. He had lost 40 pounds of weight in the several months preceding hospitalization. On the first day in the hospital he developed urinary retention due to an enlarged prostate and thereafter had a mild urinary sepsis. Preparation was as in the previous cases plus a retention catheter (Chart 10). When his temperature leveled off below 100 degrees F. a jejunostomy was performed because a gastrostomy was not feasible in face of the extensive involvement of the cardiac end of the stomach by carcinoma.

Besides the ease with which the wound healed (Figs. 4 and 5), this case is also interesting because of the sharp drop in the blood ascorbic acid levels and the urinary excretion of vitamin C beginning with the time that jejunal feedings were started, this despite intravenous cebione. Experiments upon guinea pigs have shown that at least in that animal the upper intestine is one of the main sites of storage of vitamin C. Did the disturbance of jejunal physiology attendant upon feedings directly into its lumen cause this drop in blood ascorbic acid level?

The question may arise as to whether any cases of wound disruption have been checked for blood cevitamic acid levels. One case that we know of is reported in the literature in which evisceration occurred and although the blood ascorbic acid level had not been deter-

mined, the autopsy findings showed other early evidences of scurvy. We may also add one case of carcinoma of the esophagus with gastrostomy in which there was a mild wound infection followed by a slow but complete dissolution of the wound. The blood ascorbic acid level taken after wound separation was 0.03 milligrams per cent.

The second case, C. L., a female patient 4 years of age, entered Passavant Memorial Hospital with an exstrophy of the bladder for the second stage of the procedure of implanting the ureters into the pelvic colon (Chart 11). She eviscerated on the sixth postoperative day. A blood ascorbic acid taken at the time of evisceration was 0.16 milligrams per cent. One gram doses of cebione were started immediately and the blood responded promptly. There was a secondary drop which was due either to high temperature, the infection in the wound, or to the distention causing disturbances of the intestinal physiology. However, the wound healed firmly despite marked distention and stitch abscesses to complicate the process.

CONCLUSIONS

1. Although, at present, there is no absolute proof of the relation of vitamin C deficiency to non-union of wounds in humans there is considerable evidence, historical, pathological, experimental, and clinical, to give strong support to the theory that a relationship exists and to encourage further study, particularly in the clinical field.

2. If the blood ascorbic acid is low and is accompanied by a history of deficient or defective alimentation of foods containing vitamin C, the patient may be considered to have also a tissue depletion.

3. Patients deficient in vitamin C may be saturated by large doses of synthetic cevitamic acid administered either by mouth or intravenously, or by adequate feedings of foods rich in vitamin C.

4. The deficient patient cannot be considered saturated until the blood level has been maintained at optimal or above for a sufficient period. These should be verified by a high urinary excretion. The latter can be determined only when the daily intake of vitamin C is known.

When such determinations are not available the deficient patient should be saturated with doses of 1 gram of cevitamic acid daily for a period of 9 to 10 days and then maintained on doses of about 300 to 500 milligrams of cevitamic acid daily until the wound is healed. The patient may then be kept saturated on a diet including adequate vitamin C containing foods.

5. The excretion by way of feces of vitamin C is negligible except in the presence of hypermotility of the small intestine or in alcoholics.

6. Vitamin C deficiency should be thought of and determinations made in the following types of patients: (a) Those with a deficient diet—voluntary, because of low income, or because of a doctor's dietary orders; (b) those taking large doses of alkalies by mouth; (c) those with obstructive gastro-intestinal lesions, particularly at the pylorus or above; (d) those with a history of vomiting over long periods; (e) those with hypermotility of the small intestine; and (f) syphilitics and alcoholics.

7. After operation normal patients may show a drop to scurvy levels because of long periods of intravenous therapy without food by mouth, because of abnormal bowel physiology, and because of the increased utilization of vitamin C that apparently accompanies infections and operative procedures.

We wish to express our appreciation to Dr. Chester Farmer and the Division of Chemistry for their assistance.

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SWEATING FUNCTION OF TRANSPLANTED SKIN

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THE regeneration of sensation in transplanted skin has been the subject of recent study by several investigators. The varied findings as reported have given rise to academic discussion as to the type of graft in which sensation is re-established earliest and the mechanism by which the nerve supply is restored.

Kredel and Evans, in 1933, J. S. Davis and Kitlowski, in 1934, and Loyal Davis, in 1934, have reported studies which show that sensation returns earliest and is most complete in transplants of skin which have been moved to their new locations by means of pedunculated flaps. Next in rate of return of sensation was the whole thickness graft, then the thick split, and finally the Ollier-Thiersch graft. Their observations showed that the rate and degree of return of sensation are directly proportional to the thickness of the graft. Further evidence was submitted in agreement that the return of sensation begins at the periphery of the graft in its proximal portion, progressing distally and from the sides. In disagreement with these findings is the report of McCarroll, in 1938, in which a detailed study of 58 grafts is recorded. He found that in thick split grafts the regeneration usually occurs simultaneously over the entire graft, and that in this type of graft the return is more rapid than in any other. The clinical importance of this academic argument lies in the necessity for the choice of a graft in which the earliest return of good sensation can be expected for covering defects where sensation is needed for proper function. Surgical literature abounds with comparisons of the relative merits of the different free grafts of skin, preference being given to the thick split graft by some authors who emphasize its ease of application. By others the whole thickness graft is preferred because it is movable on the underlying tissues, because it resists potential contraction and withstands ordinary cutaneous trauma, and because it matches the adjacent skin better not only in color but also in texture.

In the many neurological studies made with regard to return of sensation in grafts, little mention is made of the sweating function of the skin after transplantation. Since the secretion of moisture onto the surface of one type of graft would make it preferable to others, a comparative study of the sweating function of the various types of skin grafts has been carried out. Information has been gathered from observations on 75 grafts. Only 2 references have been found in the literature concerning the sweating function of transplanted skin. Kredel and Evans reported a case of Phemister's in which a visor flap, used for reconstruction of the upper lip, was observed to sweat only at the upper angles and along one border of the flap. Brief reference was made to another case in which a pedunculated flap, transplanted from one leg to the other showed a few small areas of sweating in its upper portion. Guttman reported observations of the sweat test on one case in which tissue had been transplanted from the anterior thoracic region to the hand by means of a tubed flap. Because the transplanted tissue sweated profusely and to the same degree as the skin of the thoracic wall, he inferred that sweat glands in skin transplanted by means of tubed flaps retain the sweating function of the donor area.

It is at once apparent that a number of factors may influence findings in the study of the sweating function of the skin. Consideration of the histological structure of the skin of the donor area is of first importance since sudoriparous glands are few in the skin and subcutaneous tissues over some parts of the body and abundant in others. Likewise, the condition of the bed to which the graft is transplanted represents a factor since scar tissue, deep to the graft, may prevent the vas-

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TABLE I.—SMALL DEEP GRAFTS

Graft No.	Case No.	Age	Location of graft	Diagnosis	Size of grafted area—cm.	Donor area	Interval between operation and test	Sweating response	Remarks
1	M.A., 75668	10	Dorsum of foot	Traumatic wound	6 by 8	Anterior thigh	2 yrs.	0	Scar underlying grafts
2	Y.P., 158442	19	Dorsum of foot	Glomus tumor	5 by 5	Anterior thigh	10 mos.	0	Subcutaneous tissue excised
3	E.H., 46900	40	Dorsum of foot	Abscess of foot	6 by 8	Anterior thigh	6 mos.	0	Scar underlying grafts
4	S.R., 73841	15	Over sacrum	Traumatic wound	10 by 14	Anterior thigh	13 mos.	0	Subcutaneous tissue avulsed
5	S.B., 160814	50	Upper arm	Traumatic wound	14 by 12	Anterior thigh	2 yrs.	0	Scar tissue under graft
6	M.P., 107690	27	Over sacrum	Pilonidal sinus	6 by 8	Anterior thigh	3 yrs.	Slight	No underlying scar tissue
7	P.S., 162612	25	Over sacrum	Pilonidal sinus	5 by 6	Anterior thigh	2 yrs.	0	Underlying scar tissue
8	G.O., 18248	56	Back of neck	Carbuncle	5 by 5	Anterior thigh	3 yrs.	0	Underlying scar tissue
9	S.W., 99066	22	Lower leg	Compound fracture	6 by 4	Anterior thigh	2 yrs.	0	Underlying scar tissue
10	L.B., 105527	40	Thoracic region	Burn scar	40 by 30	Anterior thigh	2 yrs.	0	Underlying scar tissue
11	F.G., 127798	40	Thigh	Burn scar	8 by 12	Anterior thigh	1 yr.	0	Underlying scar tissue
12	M.H., 109411	14	Leg	Angioma	8 by 6	Anterior thigh	6 mos.	0	Subcutaneous tissue excised
13	W.S., 197647	25	Amp. stump.	Traumatic wound	5 by 4	Anterior thigh	6 mos.	0	Underlying scar tissue
14	J.P., 214052	69	Back	Carbuncle	10 by 12	Anterior thigh	3 mos.	0	Underlying scar tissue
15	C.W., 125540	54	Dorsum of foot	Abscess	9 by 14	Anterior thigh	1 yr.	0	Underlying scar tissue

odilatation which accompanies diaphoresis. Also, it seems likely that grafts which are cut at a level superficial to the sweat glands of the corium, such as the Ollier-Thiersch graft, cannot be expected to exhibit the sweating function.

The sweat tests herein reported were made on 15 cases of small deep grafts, 22 Ollier-Thiersch grafts, 15 thick split grafts, 15 whole thickness grafts, and 8 pedunculated flaps. The observations are shown in Tables I to V. In all of these the thermoregulatory type of sweating was induced by means of external heat. The sweat tests were carried out according to the technique of Minor. This is as follows:

The part of the body which is to be studied is uniformly painted with the following solution: Iodine (chemically pure), 1.5 to 2 grams; castor oil, 10 cubic centimeters; absolute alcohol to 100 cubic centimeters.

The skin must be completely dry and clean before this mixture is applied. The solution is non-irritant and innocuous, even if the entire body is painted. However, it should not be applied to the eyelids or the external genitalia. After the mixture has dried, the skin has a greasy, dark yellowish appearance. The painted parts are then dusted with fine rice starch powder, which readily adheres to the skin. The starch should be lightly pressed into the pores of the skin with the help of a cotton powder puff, and all excess should be fanned away. The skin so prepared has a white or ivory hue. The moisture of the first sweat secreted produces an iodine-starch reaction. At first the individual openings of the sweat glands appear as fine, bluish black dots resembling poppy seeds. With increasing perspiration the fine dots enlarge gradually until they join, forming violet-black areas. At an advanced stage the excessive moisture drips down and, as it rinses off the mixture of iodine and starch, the pink color of the skin reappears. The skin can be cleansed by washing with soap and water.

RESULTS OF SWEAT FUNCTION TESTS IN DIFFERENT TYPES OF GRAFTS

Small deep grafts. Of the 15 cases reported in Table I only one showed even slight sweating. This occurred in pin-point fashion over a few of the larger and thicker grafts on the healed wounds. There was, of course, no sweating at all over the epithelial scar bridging the grafts. In all of these cases the grafts had been placed on granulating surfaces which had been grossly infected. The presence of underlying scar, and the fact that this type of graft is cut in a cone shape so that little of the deeper corium containing sudoriparous glands is included in the graft, explains the absence of sweating in this type of graft.

Ollier-Thiersch grafts. Of these 22 grafts, listed in Table II, only 1 showed slight sweat-

TABLE II.—OLLIER-THIERSCH GRAFTS

Graft No.	Case No.	Age	Location of graft	Diagnosis	Size of grafted area—cm.	Donor area	Interval between operation and test	Sweating response	Remarks
16	H.H., 73967	10	Dorsum of hand	Granulating wound from burn	5 by 5	Anterior thigh	2 yrs.	Slight	Sweating in 2 small areas
17	E.B., 16809	52	Anterior thorax	Cancer of breast	6 by 7	Anterior thigh	1 yr.	0	Subcutaneous tissue excised
18	H.B., 160230	60	Anterior thorax	Cancer of breast	8 by 6	Anterior thigh	1 yr.	0	Subcutaneous tissue excised
19	J.T., 145132	52	Dorsum of foot	Melanoma	8 by 9	Anterior thigh	1 yr.	0	Subcutaneous tissue excised
20	E.B., 111276	66	Anterior thorax	Cancer of breast	8 by 5	Anterior thigh	10 mos.	0	Subcutaneous tissue excised
21	F.M., 68401	49	Lower eyelid	Basal cell carcinoma	2 by 4	Anterior thigh	2 yrs.	0	Subcutaneous tissue excised
22	M.D., 84700	35	Anterior thorax	Carcinoma of breast	6 by 4	Anterior thigh	18 mos.	0	Subcutaneous tissue excised
23	J.K., 125375	49	Face	Squamous cell carcinoma	4 by 6	Anterior thigh	2 yrs.	0	Subcutaneous tissue excised
24	R.N., 113268	50	Anterior thorax	Cancer of breast	7 by 3	Anterior thigh	12 mos.	0	Subcutaneous tissue excised
25	W.B., 177895	36	Lower calf	Hemangioma	6 by 5	Anterior thigh	1 yr.	0	
26	H.K., 198417	40	Anterior thorax	Cancer of breast	6 by 4	Anterior thigh	11 mos.	0	Subcutaneous tissue excised
27	F.M., 175206	71	Nose	Basal cell carcinoma	3 by 3	Anterior thigh	1 yr.	0	Subcutaneous tissue excised
28	J.N., 41826	63	Anterior thorax	Cancer of breast	8 by 6	Anterior thigh	10 mos.	0	Subcutaneous tissue excised
29	A.T., 185125	52	Dorsum of foot	Melanoma	4 by 6	Anterior thigh	1 yr.	0	Subcutaneous tissue excised
30	E.J., 153569	49	Anterior thorax	Cancer of breast	7 by 5	Anterior thigh	9 mos.	0	Subcutaneous tissue excised
31	L.B., 59950	41	Anterior thorax	Cancer of breast	7 by 4	Anterior thigh	10 mos.	0	Subcutaneous tissue excised
32	E.J., 153567	49	Anterior thorax	Cancer of breast	6 by 4	Anterior thigh	1 yr.	0	Subcutaneous tissue excised
33	R.B., 18899	46	Anterior thorax right	Cancer of right breast	7 by 4	Anterior thigh	2 yrs.	0	Subcutaneous tissue excised
34	R.B., 18899	46	Anterior thorax left	Cancer of left breast	8 by 4	Anterior thigh	2 yrs.	0	Subcutaneous tissue excised
35	C.M., 166291	32	Anterior thorax	Cancer of breast	8 by 5	Anterior thigh	2 yrs.	0	Subcutaneous tissue excised
36	D.P., 127530	39	Anterior thorax	Cancer of breast	8 by 4	Anterior thigh	1 yr.	0	Subcutaneous tissue excised
37	C.B., 159370	49	Anterior thorax	Cancer of breast	8 by 5	Anterior thigh	1 yr.	0	Subcutaneous tissue excised

ing, limited to 2 very small areas. In that case (graft No. 16) all of the subcutaneous tissue had not been destroyed by the burn and underlying scar was minimal. In the 21 other cases (grafts Nos. 17 to 37) all of the subcutaneous tissue had been excised at the time of operation. The total absence of any sudoriparous glands in the grafts or in the underlying tissues explains the absence of the sweating function.

Thick split grafts. Of the 15 grafts of this type listed in Table III only 2 showed any sweating. In 1 case (graft No. 46) the thick split graft was applied to the palm of the hand in the technique of Lotheissen's operation for Dupuytren's contracture. The graft was applied to a clean surface of healthy subcutaneous tissue in a region abundant with sweat glands. In the other case (graft No. 51) the thick split graft was applied to the surface of a wound in the process of healing after a burn. The subcutaneous tissue and some of the corium had survived the burn. In the 13 other cases (grafts Nos. 38, 39, 40, 41, 42, 43, 44, 45, 47, 48, 49, 50, 52) either the subcutaneous tissue was excised completely at the time of operation or there was evidence of excessive scar underlying the graft. The results of these tests indicate that the thick split graft does not exercise the function of sweating.

Whole thickness grafts. The result of the sweat test in 15 whole thickness grafts (Table IV) shows that all but one had a positive sweating response. In this case (graft No. 59) in which the graft was located on the lower lip, hypertrophic scar formation was present around and under the graft, elevating

TABLE III.—THICK SPLIT GRAFTS

Graft No.	Case No.	Age	Location of graft	Diagnosis	Size of grafted area—cm.	Donor area	Interval between operation and test	Sweating response	Remarks
38	R.R., 140574	12	Buttock	Burn scar	12 by 14	Anterior thigh	1 yr.	o	Scar tissue underlying graft
39	B.H., 86722	50	Anterior thorax	Cancer of breast	8 by 6	Anterior thigh	1 yr.	o	Subcutaneous tissue excised
40	W.S., 169186	9	Upper arm	Traumatic wound	14 by 9	Anterior thigh	10 mos.	o	Subcutaneous tissue excised
41	R.P., 40640	38	Anterior thorax	Cancer of breast	8 by 5	Anterior thigh	2 yrs.	o	Subcutaneous tissue excised
42	N.H., 158522	54	Cheek	Cancer of face	4 by 3	Anterior thigh	10 mos.	o	Subcutaneous tissue excised
43	E.H., 46900	42	Anterior thorax	Cancer of breast	7 by 4	Anterior thigh	6 mos.	o	Subcutaneous tissue excised
44	M.D., 187200	32	Dorsum of hand	Traumatic wound	8 by 6	Anterior thigh	5 mos.	o	Scar tissue underlying graft
45	E.N., 140786	57	Anterior thorax	Cancer of breast	6 by 4	Anterior thigh	1 yr.	o	Subcutaneous tissue excised
46	F.H., 25299	50	Palm of hand	Dupuytren's contraction	5 by 3	Anterior thigh	11 mos.	Slight	Sweating limited to one area 1 cm. square
47	E.M., 103648	48	Anterior thorax	Cancer of breast	6 by 6	Anterior thigh	10 mos.	o	Subcutaneous tissue excised
48	V.R., 42231	52	Anterior thorax	Cancer of breast	9 by 5	Anterior thigh	1 yr.	o	Subcutaneous tissue excised
49	M.G., 112093	35	Eyelid	Traumatic ectropion	2 by 2	Anterior thigh	6 mos.	o	
50	M.T., 125138	40	Upper arm	Lipoma of arm	6 by 6	Anterior thigh	9 mos.	o	Subcutaneous tissue excised
51	M.L., 70043	19	Anterior thorax	Burn scar	6 by 4	Anterior thigh	14 mos.	Slight	Sweating limited to one area 1 cm. square
52	A.S., 14748	49	Anterior thorax	Cancer of breast	6 by 4	Anterior thigh	16 mos.	o	Subcutaneous tissue excised

TABLE IV.—WHOLE THICKNESS GRAFTS

Graft No.	Case No.	Age	Location of graft	Diagnosis	Size of grafted area—cm.	Donor area	Interval between operation and test	Sweating response	Remarks
53	M.O., 135598	64	Lower eyelid	Cancer of eyelid	3 by 2	Upper eyelid	6 mos.	Slight	Subcutaneous tissue excised
54	H.M., 155708	21	Cheek	Mole	2 by 2	Postauricular area	6 mos.	+	
55	Y.B., 79438	52	Ulnar side of palm	Cancer of hand	3 by 3	Inner aspect upper arm	1 yr.	Slight	Subcutaneous tissue excised
56	J.A., 176680	27	Cheek	Burn scar	3 by 3	Postauricular area	6 mos.	Slight	Scar underlying graft
57	H.M., 169954	21	Lower eyelid	Ectropion burn scar	3 by 3	Postauricular area	7 mos.	Slight	
58	J.D., 12445	22	Lower eyelid	Ectropion burn scar	2 by 3	Upper eyelid	10 mos.	+	
59	E.B., 179409	14	Lower lip	Hairy mole	3 by 3	Postauricular area	1 yr.	o	Hypertrophic scar under graft
60	R.G., 206057	5	Upper arm	Hairy mole	8 by 10	Abdomen	9 mos.	+	
61	C.M., 120042	2	Finger	Congenital contracture	3 by 2	Abdomen	9 mos.	+	
62	M.F., 132306	43	Finger	Contracture	4 by 3	Inner arm	1 yr.	++	
63	A.R., 122762	19	Eyelid	Ectropion	3 by 2	Postauricular area	1 yr.	+	
64	F.G., 182097	27	Thigh	Burn scar	20 by 8	Lumbar region	10 mos.	+	
65	M.C., 28343	12	Groin	Burn scar	11 by 4	Lumbar region	1 yr.	+	
66	H.H., 73967	27	Groin	Burn scar	12 by 7	Lumbar region	1 yr.	+	
67	S.L., 119004	75	Temporal region	Melanoma	5 by 5	Abdomen	6 mos.	Slight	Subcutaneous tissue excised

TABLE V.—PEDUNCULATED FLAPS

Graft No.	Case No.	Age	Location of graft	Diagnosis	Size of grafted area—cm.	Donor area	Interval between operation and test	Sweating response	Remarks
68	H.H., 73967	10	Flexor surface of wrist	Burn scar	8 by 8	Abdomen	2 yrs.	+	
69	J.R.	27	Cheek	Traumatic scar	7 by 7	Anterior cervical region	2 yrs.	+	
70	M.L., 25145	26	Palm	Burn scar	7 by 6	Abdomen	2 yrs.	+	
71	F.C., 145025	19	Anterior cervical region	Burn scar	8 by 10	Lumbar region	10 mos.	+	
72	G.G., 113671	10	Upper arm	Amniotic bands	9 by 5	Thoracic region	10 mos.	+	
73	H.L., 85255	52	Upper lip	Cancer of lip	3 by 6	Cervical region	11 mos.	+	
74	F.H., 75437	67	Ear	Microtia	2 by 6	Cervical region	5 mos.	Slight	Flap contained cartilage
75	P.S., 185532	51	Wrist	Carcinoma	6 by 10	Abdomen	3 mos.	Slight	

it above the surface of the skin and giving to it the appearance of a keloid although the graft itself had survived completely. This underlying scar probably interfered with the development of the hyperemia associated with sweating. In the case which exhibited a marked degree of sweating, the graft had been taken from the inner aspect of the arm near the axilla, an area abundantly supplied with sweat glands. The results of these tests are in keeping with expectation based on a study of the microscopic anatomy of the skin, for the reason that sweat glands are known to be present not only in the subcutaneous tissue but also in the corium, many of them being transplanted with the whole thickness type of skin graft.

Pedunculated flaps. In all of these 8 cases some degree of sweating was evidenced. The transplantation of a block of skin with its subcutaneous tissue leaves the sweat glands of the transplant undisturbed except, of course, for the fact that the nerves and blood vessels to the area must be re-established. In this series of observations no adequate information has been gained as to how soon after transplantation of skin and subcutaneous tissue by means of a pedunculated flap, the sweating function is re-established; nor can inference be drawn as to whether or not the re-establishment of the sweating function must be preceded by the regeneration of sympathetic nerves to the skin. It is known that the sweat glands of the skin are abundantly supplied with capillary vessels and small non-medullated nerves which form plexuses about the walls of the coiled portion of the gland and from which terminal fibrils penetrate the basement membrane to end in contact with the secreting cells. The earliest time that sweating was observed in this series (graft No. 75) was 3 months. This graft was located on the wrist of the patient. Since it has been observed that sensation to pain may return completely as early as 65 days after transplantation of tissue by means of a pedunculated flap, it is possible that the regeneration of the regional sympathetic nerves is a necessary part of the re-establishment of the sweating function of the flap.

SUMMARY AND CONCLUSIONS

The results of a study of the sweating function of transplanted skin are reported. Of the 75 grafts studied, whole thickness grafts and those transplanted by means of pedunculated flaps were found to be capable of sweating, while small, deep, Ollier-Thiersch, and thick split grafts were not.

The age of the individual apparently is not an influencing factor.

The findings indicate that the re-establishment of the sweating function of the skin depends certainly upon the presence of sudoriparous glands in the transplant.

This study gives no information on the question as to whether or not the sympathetic nerve fibers to the grafts of skin must be re-established before the sweating function can take place.

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ACETYLCHOLINE AS A DIAGNOSTIC TEST IN CASES OF CONGENITAL MEGACOLON

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THE success of sympathectomy for congenital megacolon depends on the extent of the lesion and the state of the colonic musculature. In a study of 10 patients (2) it was found that while some show marked muscular hypertrophy others come to autopsy or are seen during laparotomy with extreme thinning out of the colonic wall and a complete loss of musculature.

From the Department of Surgery, University of Illinois, College of Medicine, and St. Luke's Hospital.

Whether this is a congenital defect, a result of exhaustion and muscular decompensation or the nutritional effect of constant distention, is difficult to say. But the fact remains that when the muscular power of the colon is lost no type of sympathectomy can help. Morton and Scott have made an important contribution to the subject. They proposed the use of spinal anesthesia to inhibit the sympathetic outflow to the colon and demonstrated the evacuation of the colon under the anesthetic.

Fig. 1. Case of Eugene W., 7 year old boy, suffering from congenital megacolon. Barium enema obtained after 3 weeks of preparation of the colon with large warm enemas and 2 daily injections of acetylcholine. The colon filled slowly. The rectum and sigmoid are markedly dilated. The sigmoid loop is displaced into the right upper quadrant. There is a sharp kink at the highest point and the diameter of the proximal loop is not increased. The rest of the colon has filled as far as the middle third of the transverse colon, is freely movable, and looks normal.

Fig. 2. Same colon as in Figure 1, 45 minutes after the administration of 0.7 cubic centimeters of acetylcholine bromide subcutaneously. The large bowel contracted markedly and there is a definite evacuation. The mucosal pattern of the sigmoid loop is bizarre, the mucosa having the appearance of that of the upper gastro-intestinal tract. Sympathectomy resulted in daily bowel movements without drugs or cathartics.

Spinal anesthesia has been used in some of our earlier cases of megacolon as a pre-operative test. In these anxious, undernourished, poorly disciplined children a spinal anesthesia is not always easy to perform. In 3 of our last cases we resorted to stimulating the pelvic parasympathetic outflow instead of inhibiting the sympathetics. A three-fourths ampule of acetylcholine bromide in children or one whole ampule in adults produces a prompt evacuation of the barium, if muscular power is available. One ampule contains 0.1 gram of the drug. Ten milligrams of mecholyl are equally useful. One patient with a poor response showed a thin transparent membrane instead of a hypertrophied colon.

Following the slow instillation of barium, diluted with equal amounts of petrolagar, the first film is taken (Fig. 1). Forty-five minutes after the subcutaneous injection of acetylcholine a second film is obtained (Fig. 2). The drug is useful for evacuating the residual barium and for preparing the colon for operation. It has been used for periods from a week to 10 days, twice a day, without any untoward effects.

The drug is equally helpful in the treatment of postoperative, paralytic ileus as advocated by Abel. An ampule may be given every 6 hours until gas is passed or the bowels have acted without an enema.

It is a pleasure to thank Dr. E. L. Jenkinson for the facilities of the X-ray Department.

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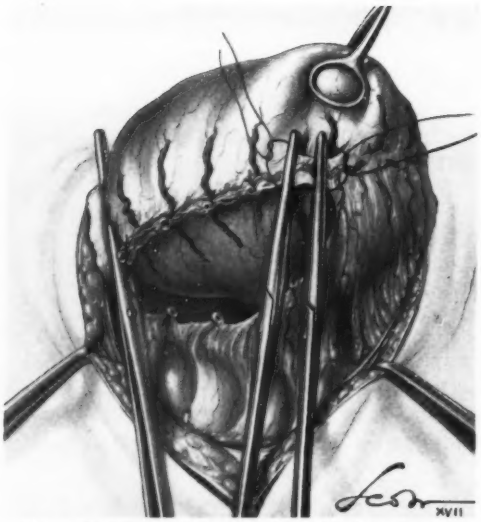


Fig. 3. Gastro-epiploic vessels ligated and greater omentum incised along greater curvature.

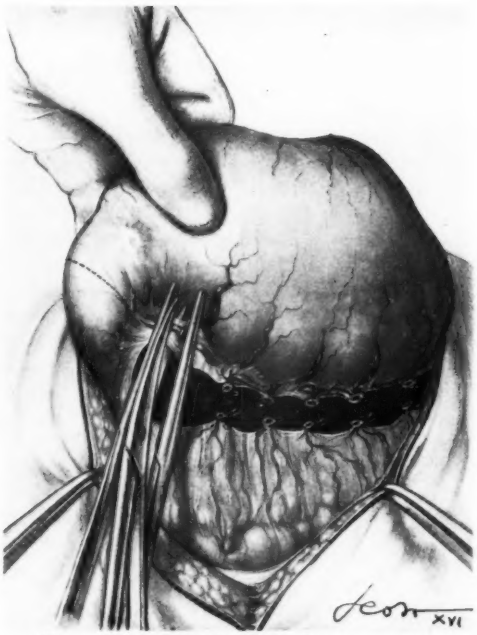


Fig. 5. Omentum incised along lesser curvature.

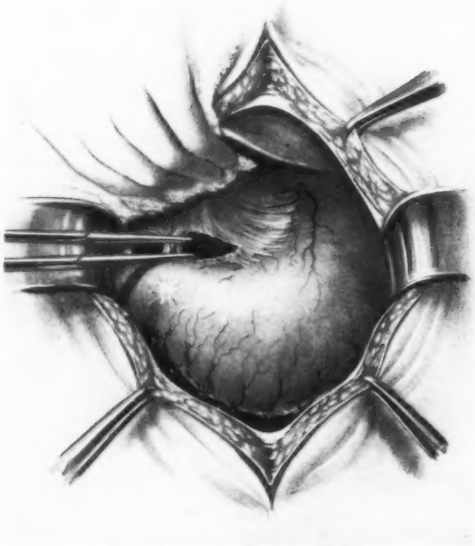


Fig. 4. Opening of lesser omentum.

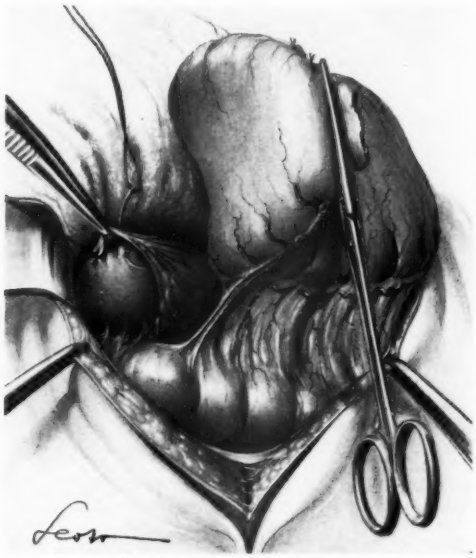


Fig. 6. Excision of duodenum.

Technique of Gastric Resection for Gastroduodenal Ulcer.—Roberto Alessandri.

CLINICAL SURGERY

FROM THE R. CLINICA CHIRURGICA

TECHNIQUE OF GASTRIC RESECTION FOR GASTRODUODENAL ULCER

ROBERTO ALESSANDRI, M.D., Rome, Italy

IN preparation for the operation under discussion the patient is made to rest in bed for 2 days, and an accurate examination of renal and cardiac functions is performed. Patients with disturbances of the respiratory apparatus are not considered in condition for operation until all signs of bronchial catarrh have disappeared. We have abandoned the use of all vaccines against eventual postoperative complications inasmuch as our experience has convinced us that preventive vaccination is useless. Thorough cleansing of the teeth, the elimination of dental caries, and the extraction of decayed roots are all essential details in preoperative preparation.

In the days preceding operation patients are placed on a light diet, essentially of carbohydrates. The night before the operation an enema is given; we never give a cathartic to our patients. In the presence of pyloric stenosis, we do 2 gastric lavages a day on the days preceding the operation. We have observed that by so doing the stenosis is generally diminished, probably because the muscular wall of the stomach, which is no longer distended, picks up in tone and contractile power.

The operation is usually performed under local anesthesia preceded by basal anesthesia. We have used, with good results, both "preanest, Zambelletti" and the "dilaudid-scopolamine, Knoll." These substances are first injected 1½ hours before operation and again a half hour before. Usually camphor or a digitalis compound is also injected. In patients with pyloric stenosis, in those who are generally depressed, or in very old patients a half or three-quarters of a dose is sufficient to obtain the required results. The patient is placed on the operating table with a pillow under the base of the thorax so as to render the deep organs more accessible.

Anesthesia is produced by infiltrating systematically the skin, the subcutaneous tissue, and the properitoneal fat along the linea alba. Besides local anesthesia we use regional anesthesia, which is secured by injecting the anesthetic into the sheath of the rectus muscle and into the subcutaneous tissue at a distance of 3 to 4 centimeters from the linea alba. We use a 0.5 per cent solution of novocain or a 0.2 per cent solution of tutocaine; about 120 to 150 cubic centimeters are sufficient.

Incision. The incision is xipho-umbilical and rarely prolonged below the umbilicus (Fig. 1). Having provided for hemostasis, we fix the peritoneum to the towels so as to exclude the subcutaneous tissue and the skin from contact with the viscera.

Exploration should always be accurate, and the lesser curvature should always be exam-

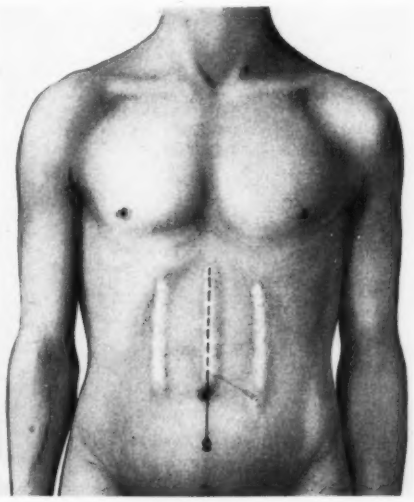


Fig. 1. Incision of the abdominal wall.

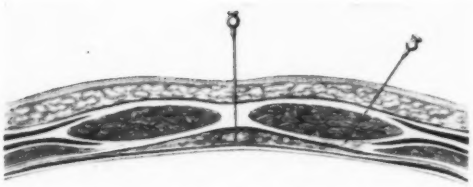


Fig. 2. Anesthesia along linea alba and rectus muscle sheath.

ined even when a duodenal lesion is immediately evident. We always perform resection thus attempting to remove the duodenal ulcer. We have noticed, even in cases of deep ulcers penetrating into the surrounding organs, that it has been possible to remove the ulcer completely with accurate resection. Only in rare cases in which the general condition (age and weakness) was very poor have we abandoned the use of resection.

In the last few years we have performed radical resection in 90 per cent of the cases. In those patients in whom the ulcer is particularly deep we prefer to perform gastro-enterostomy rather than the palliative resection proposed by Finsterer. However, I am convinced that with accurate dissection it is possible to free and remove ulcers which at first might appear to present unsurmountable difficulties.

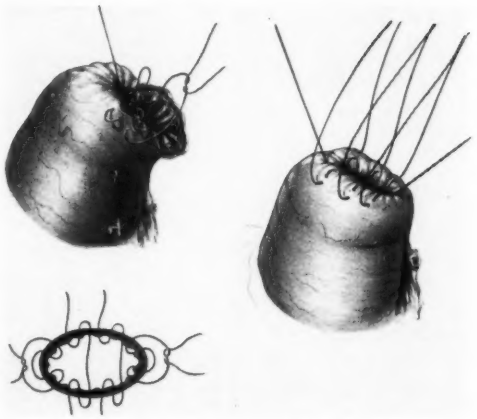
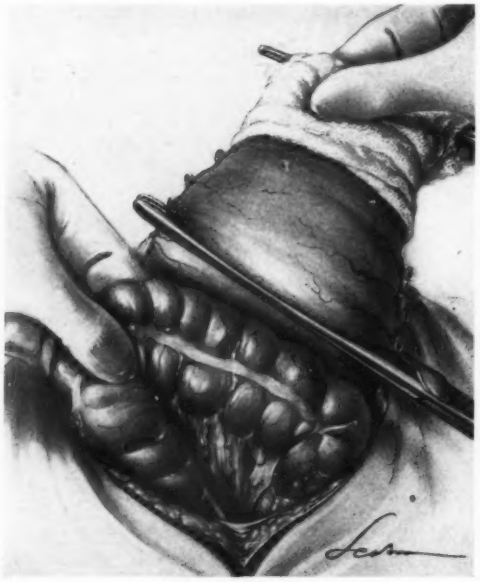
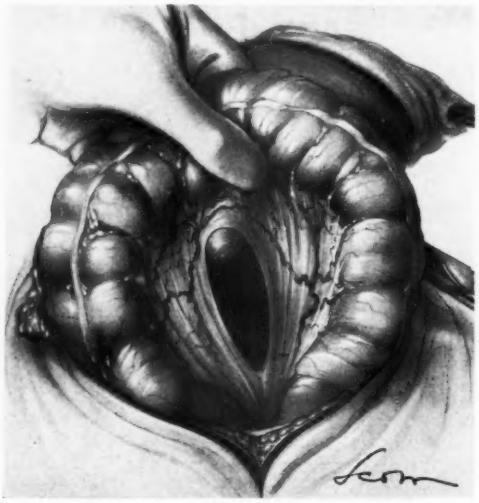


Fig. 7. Closing and peritonization of duodenum.

The limits of resection are bounded on the left by the outlet of the left gastric vein on the lesser curvature, and on the greater curvature at a point corresponding to the direction of the blood vessels. With a Kocher forceps at this point along the greater curvature, the gastro-epiploic ligament is opened and the left gastro-epiploic vein is clamped near the greater curvature. After having applied another hemostatic clamp in a chosen place, the blood vessel is cut. Then a finger is introduced across the epiploic opening into the posterior omental cavity (Fig. 3); 2 more hemo-





Figs. 8, left, and 9. Transverse colon. Opening of mesocolon.

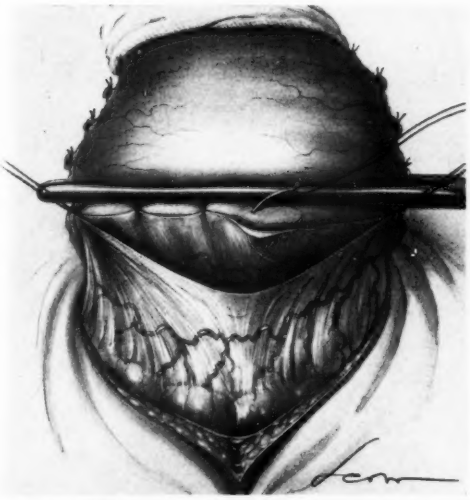


Fig. 10. Fixing mesocolon to posterior gastric wall.

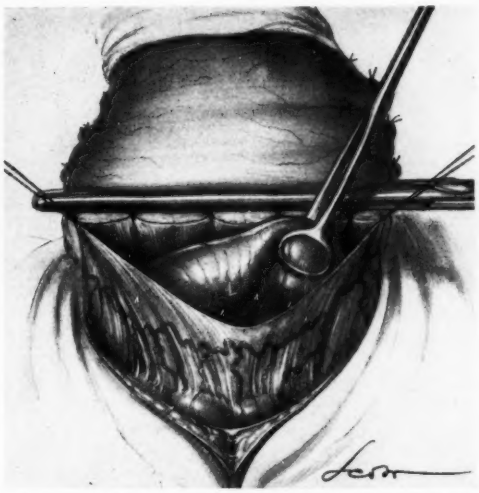


Fig. 11. Jejunum coming through mesocolon opening.

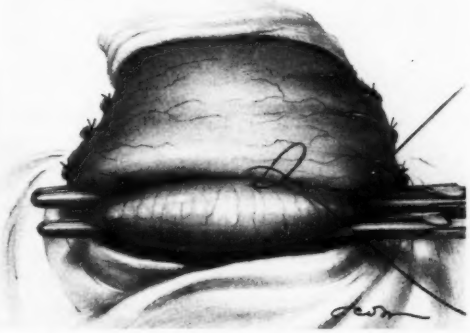


Fig. 12. Anastomosis by continuous silk sutures.

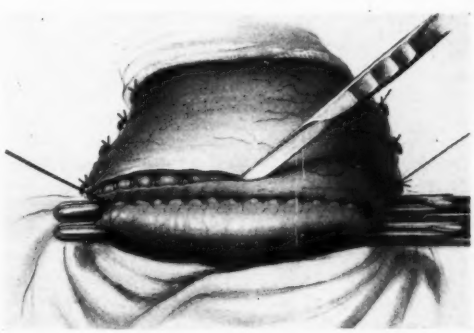


Fig. 13. Cutting the seromuscular layer.

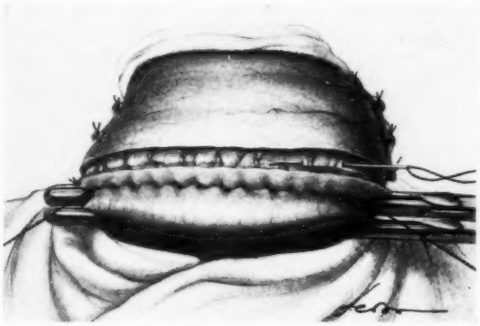


Fig. 14. Seromuscular layer severed.

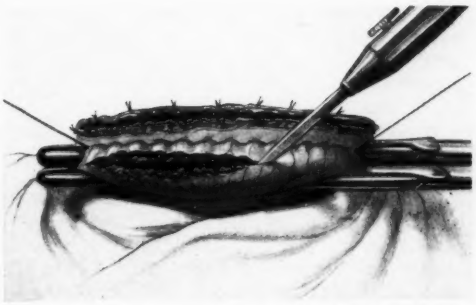


Fig. 15. Cutting the mucosa with electric knife.

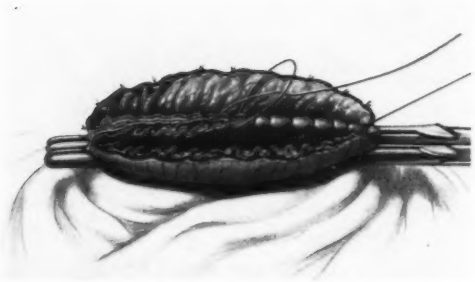


Fig. 16. Continuous suture in process.

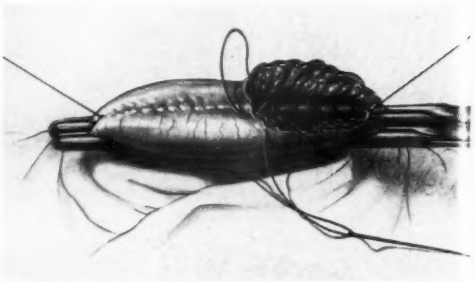


Fig. 17. Suturing anterior wall of stomach and intestine.

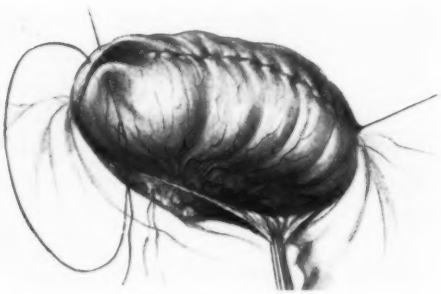


Fig. 18. Seromuscular suture.

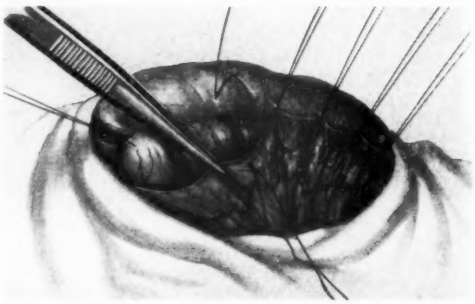


Fig. 19. Closing mesocolic opening to complete operation.

static clamps are applied to the vessels which leave the gastro-epiploic vein and go to the colic insertion of the omentum. Generally with 5 or 6 consecutive clampings the greater curvature is completely freed. Following this, the severed blood vessels of the greater omentum are ligated. Eventual adhesions between the posterior surface of the stomach and the mesocolon are removed. Then, introducing a finger behind the stomach, the lesser omentum is pierced in an avascular zone (Fig. 4). Proceeding from this point, the lesser curvature is lifted, thereby putting tension on the lesser omentum, as has been described previously for the greater curvature, and the lesser curvature is isolated as far as the right gastric artery which is cut (Fig. 5).

We then proceed to free the duodenum. This is always begun from the outer surface below the ulcer, in a direction toward the pylorus, never away from it. The ulcer frequently penetrates into the hepatoduodenal ligament, and the latter is freed by cutting into the infiltrated ligament, always keeping near the ulcer. In this way, a possible lesion of the common bile duct is avoided. The freeing of the posterior wall of the duodenum, always below the ulcer, proceeds from the duodenum toward the pylorus.

Having thus freed the ulcer and without applying an intestinal clamp, we resect the duodenum with scissors at the inferior margin of the ulcer and fold the stomach toward the left. The duodenum is sutured with separate stitches of No. 0 catgut, according to Connell's method, starting from the superior angle. A second series of individual silk stitches is applied and finally provision is made for peritonization by uniting with silk stitches the free margin of the peritoneum that invests the pancreas, where it was severed by the dissection of the duodenum, and the external surface of the duodenum (Fig. 6).

Across a breach in the mesocolon, obtained as described, the first loop of the jejunum is found and exposed (Figs. 8–11). The left margin of the mesocolic breach is fixed with silk stitches to the posterior surface of the stomach from the greater to the lesser curvature at the point where the left gastric artery was ligated. The use of intestinal and stomach clamps is not indispensable. The anastomosis is done in a double line and precisely with a continuous seromuscular suture in silk (Fig. 12).

Having completed the posterior line of suture, the muscular layer of the posterior surface of the stomach is cut so as to expose the blood vessels of the submucous stratum (Figs. 13, 14). With individual stitches of catgut the greater blood vessels are ligated along the posterior surface. With the electric knife the mucosa of the stomach is cut and immediately after the jejunum is opened and a total continuous suture is made (Figs. 15, 16).

After the suture has been completed the stomach is unfolded toward the right and the muscular layer is cut along the anterior surface, followed by hemostasis of the blood vessels of the submucous stratum by means of individual stitches. By cutting the mucosa the portion of the stomach resected will be free (Fig. 17).

The complete anterior suture is done by inverting stitches in a manner similar to that used for the posterior suture, that is, by first piercing the mucosa, crossing the 2 muscular layers and coming out through the mucosa, looping the stitch after the needle has come out.

Finally, the anterior seromuscular suture is done as a continuous suture (Fig. 18). The jejunum is replaced across the opening in the retromesocolic space, and the right margin of the mesocolic breach to the anterior gastric wall is sutured at about a centimeter above the gastrointestinal anastomosis (Fig. 19). The different layers of the abdominal wall are then sutured.

Postoperative treatment. After the operation the patient is directly transferred from the operating table to his own bed which has been brought to the operating room. He is placed in a sitting posture and in a few hours rectoclysis is begun.

The night after operation morphine and cardiotonics are given. The following morning gastric lavage is performed. This is done with a Fremont tube, and a luke warm 2 per cent solution of bicarbonate of soda; in this way a certain amount of bloody and ill-smelling gastric residue is removed. After this the patient can take a few sips of water. Night gastric lavage is repeated. Generally 2 such lavages are sufficient. However, if there still remains a great amount of residue, further lavages can be done in the days following.

To prevent postoperative complications we have the patients inhale carbon dioxide. A liquid diet is given for the first 5 days; milk is permitted on the third day; on the sixth day broths, soups, and cooked fruit are given. The patient is allowed to get up on the tenth day.

Postoperative complications. The most frequent complication is gastric stasis which sometimes lasts until the fifth or sixth day. Respiratory complications are frequent but not serious and I believe that they are of an atelectatic nature rather than bronchopneumonia lesions, because, granted that the physical signs speak for bronchopneumonia, the rapid course of the condition and the rise in temperature point to an atelectatic lesion.

If hemostasis of the blood vessels of the gastric mucosa has been properly done the danger of hemorrhage can be completely avoided. We use blood transfusions ranging from 400 to 500 grams in long suffering patients and in those in poor physical condition in order to prevent and eventually ward off operative shock. Peritoneal complications are rare. The possibility of sutures giving way is exceptional. The death rate, which is 2–3 per cent, is due almost wholly to respiratory complications.

FRACTURES OF THE CLAVICLE

Ambulatory Treatment by Suspension-Elevation

ROGER ANDERSON, M.D., F.A.C.S., Seattle, Washington

IT may well be said about fractures of the clavicle that "familiarity breeds contempt," for few bony injuries are so lightly regarded. The willingness on the part of most physicians to treat these fractures might tend to indicate that little skill is required and that end-results are uniformly good. Unfortunately, such is not the case, and any illusions as to the anatomical excellence of end-results will quickly be dispersed by a review of the final roentgenograms of any consecutive group of cases.

Despite achievement of bony union and restoration of function, the high incidence of deformity and shortening convincingly demonstrates that current ambulatory methods do not fulfill the basic requirement of an anatomical reduction *maintained* throughout healing.

The problem of treatment is further complicated by the increasing number of fractures of the clavicle occurring in adults. Adult bone does not possess the reconstructive ability inherent in the growing bone of children, hence with these fractures in adults, unsightly deformities are a persistent reminder of the inadequacy of treatment. A number of physicians, so disappointed with results obtained by ambulatory treatment, routinely confine adult patients to bed, and not a few men insist upon recumbent treatment for fractures of the clavicle in children as well.

A simple, scientific, ambulant method of treatment that actually maintains correct alinement of the fractured clavicle throughout healing would be a welcome addition to the fracture technique not only of the general physician, but of the experienced bone specialist as well.

CLINICAL ANATOMY

The vulnerability of the clavicle lies not so much in its structure as its location, representing as it does, the only bony strut between the axial skeleton and the upper extremity. A significant functional responsibility accompanies this important anatomical position, the action of the clavicle being comparable to that of the boom stick of a derrick.

Since the scapula has no direct bony attachment to the spine or thorax, the sternoclavicular joint is a keystone center of movement for both the clavicle and scapula, i.e., the *fulcrum* of the shoulder girdle. The strong ligamentous structures around the sternoclavicular joint have led anatomists to believe that the joint did not permit a great deal of movement. This misconception will be quickly corrected by combined roentgenographic and physical studies of the normal *living* shoulder. Such methods will disclose a number of facts, not ordinarily stressed, but useful in treatment. Of these, 4 may be mentioned.

1. Elevation of the clavicle. By shrugging the shoulder or reaching toward the ceiling with the outstretched hand, the clavicle can be elevated 75 degrees or greater in the normal adult (Figs. 1a and b). This clavicular movement takes place at the sternoclavicular joint.

The scapula is attached to the outer end of the clavicle, and must also be elevated during such a shrugging action. The center of movement of the scapula depends chiefly upon the structure of both clavicular joints. Since the acromioclavicular joint permits but a limited degree of motion, scapular movement will center chiefly upon the sternoclavicular joint. The ultimate position of the scapula depends upon various other factors, such as the elasticity and strength of the soft tissues which surround it and are attached to it.

Maximum elevation of the clavicle is more freely accomplished when the shoulder girdle is lifted up in the neutral, sagittal plane. As either anterior or posterior shifting of the shoulder girdle occurs, the scapular centers of movement shift accordingly, muscle and ligamentous relationships are altered, and the degree of possible elevation becomes progressively more difficult. Therefore, one cannot freely obtain maximum elevation and maximum posterior displacement of the shoulder girdle at the same time.

2. Anterior and posterior movement of the clavicle. Anteroposterior movement of the clavicle must receive consideration when the position of immobilization is selected. Actual measurement in this plane again reveals surprising mobility of the sternoclavicular joint (Figs. 2a, b, and c). The sternoclavicular joint is situated on the front of the chest, anterior to the outer end of the clavicle. Thus as the shoulder is displaced posteriorly it must rapidly come to lie nearer the midline of the

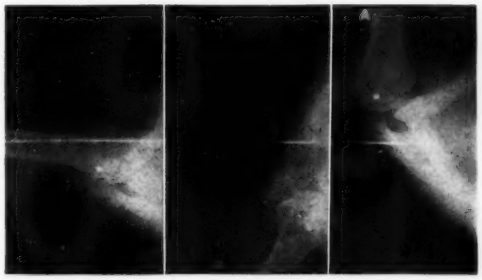
Fig. 1. a, left. Left shoulder girdle of a normal, middle-aged male, arm hanging loosely at side. b, Same shoulder as in Figure 1a. X-ray tube, film, and spine were unchanged while shoulder has been actively shrugged. Observe the striking degree of normal elevation of the outer end of the clavicle, permitting it almost to parallel the spine. This elevation centers at the sternoclavicular joint. Observe that scapular movement has also centered upon both the sternoclavicular and acromioclavicular joints and not through the anatomical center of the bone.

body. When the shoulder is shifted anteriorly, however, it moves away from the midline until the two clavicular joints are in the same frontal plane. Further forward movement will then cause the shoulder to move inward again.

3. *Rotation of the clavicle.* The clavicle will rotate in its long axis frequently to a degree permitting the inferior surface to look almost directly anterior (Figs. 3a, b, and c). Rotatory displacement in clavicular fractures may be especially accentuated by swinging the arm and shoulder forward and upward. If fractures of the clavicle are being treated in bed by suspension of the arm in such a position, roentgenograms should be inspected for the presence of this type of displacement.

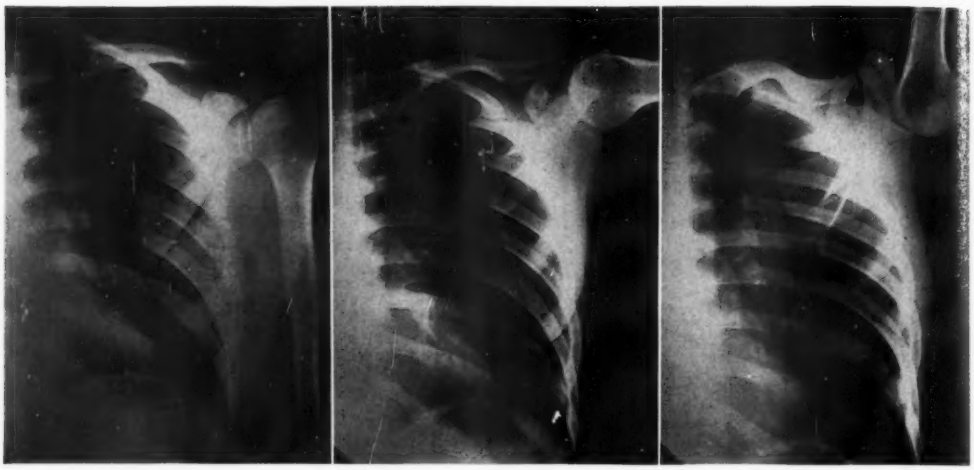
4. *Rotation of the scapula.* It is widely believed that in the act of fully abducting the arm, the scapula remains motionless during the first 90 degrees and begins to rotate only when arm abduction is continued above this level. However, in most individuals scapular rotation takes place throughout the whole of arm abduction, approximately one-third occurring during the first 90 degrees of arm abduction, the remaining two-thirds taking place as arm abduction is completed (Figs. 3a, b, and c). The resisting influence of muscles and ligaments about the shoulder girdle alter this degree and rate of scapular rotation in different individuals.

With fractures of the clavicle each fragment can be displaced with its respective joint as an axis. If fragments are to be successfully replaced by an ambulatory apparatus, points of motion and adjustment *must coincide functionally* with the centers of displacement, namely, the sternoclavicular and acromioclavicular joints.



a b c

Fig. 2. Roentgenograms of a normal adult shoulder demonstrating the long range of anteroposterior movement of the outer end of the clavicle. The x-ray tube was placed in the axilla with the arm normally abducted lateralward to 90 degrees. A wire was extended out from the base of the neck over the center of the shoulder at right angles to the spine and parallel to the frontal plane. The film was placed over the top of the shoulder. Tube, wire, and film were held in identical positions, only the shoulder moving. The letters on the films indicate the direction in which the shoulder was moved. This movement also centers at the sternoclavicular joint. The outer end of the clavicle in the neutral position is shown in a. As the shoulder is shifted posteriorly in b, the outer end of the clavicle rapidly comes to lie nearer the midline of the spine. Anterior shifting at c, on the other hand, causes the shoulder to move away from the midline until the two ends of the clavicle lie in the same frontal plane.



a b c

Fig. 3. Shoulder of a normal, young, male adult. With the x-ray tube and film unchanged, the arm has been progressively abducted lateralward in the plane of least resistance. Observe that as the position changes, the clavicle rotates in its long axis sufficient to permit the inferior surface to look almost directly forward. Also note that over one-third of the movement of the scapula has taken place during the first 90 degrees of arm abduction. The remarkable ability of the head of the humerus to glide out of the glenoid fossa in this normal and uninjured shoulder demonstrates the fundamental importance of soft tissues in maintaining shoulder joint stability. Variable elasticity of the soft tissues will directly alter, but only moderately, the degree and range of normal shoulder girdle movement.

PRINCIPLES OF TREATMENT

Most fractures of the clavicle result from force transmitted through the abducted arm to the clavicle, or from a blow directed against the shoulder itself. The fracture line is usually oblique with the common site of break in the middle third of the bone where the two normal curves meet. The usual deformity, namely, that of the shoulder with attached outer fragment falling downward and inward, has long been well understood.

The significant elements involved in reduction of the fractured clavicle consist of upward, outward, and backward replacement of the shoulder (Figs. 4a and b). Scores of methods have been used to accomplish this treatment.

Key and Conwell aptly state the situation as follows:

"—more than 200 different methods have been described and recommended for the treatment of fractures of the clavicle. This is, of course, evidence that we have no method which is satisfactory to the majority of surgeons. . . . the displacement can be reduced by simply pulling the shoulder backward, outward, and upward; but this reduction is almost impossible to maintain in an ambulant patient because any form of dressing or apparatus which maintains anatomic reduction will be intolerant to the patient."

Clinical experience has incontrovertibly convinced us that the basic maneuver for successful reduction is elevation; and that when adequate elevation of the shoulder is sustained, the fragments will be fixed, yet the arm may be freely and painlessly moved without disturbing the fracture site. Displacing the shoulder far posteriorly, the basic idea of many of the current treatments, is not so necessary when a practical method of supplying the desired degree of elevation is provided. In fact, with an accurate physiological means for immobilizing the shoulder girdle in any desired position, one is more and more impressed with the fact that frequently the best reductions will be had by merely replacing the outer fragment up to, or slightly above, the normal neutral position.

Shortening, the distressful factor with most fractures, is doubly difficult to maintain corrected in the clavicle because not only strong muscle contraction but the pull of gravity on the arm must be overcome. Experience with extremity fractures has proved that the effectiveness of the traction varies directly with the coincidence of the line of pull to that of the extremity. A successful treatment must, therefore, be one that exerts traction in direct line with the long axis of the clavicle. By the elevation of the shoulder in the normal sagittal body plane, traction on the

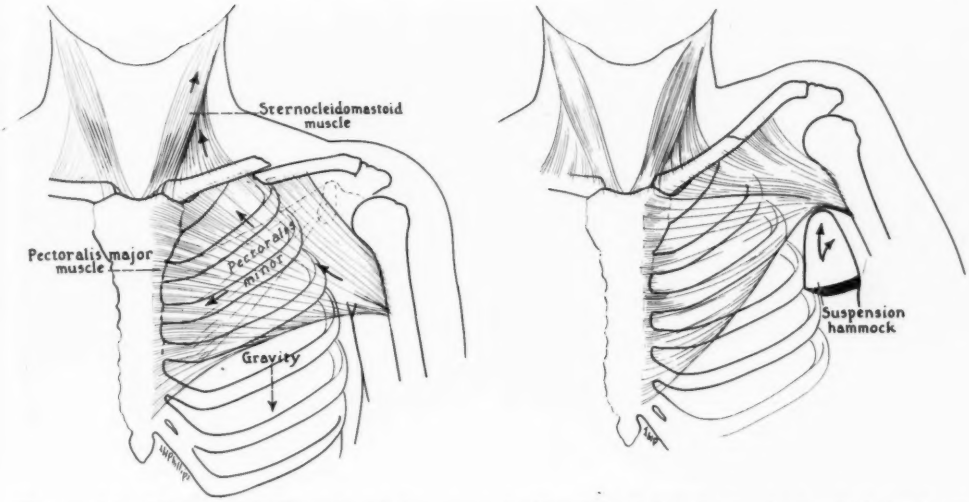


Fig. 4. a, left. Diagrammatic illustration of the common deformity following fracture of the clavicle with the displacing forces shown. b, Reduction obtained by suspending a suitable hammock in the axilla and elevating the shoulder. The pull of gravity, previously a displacing factor, is now favorably utilized to supply lateral traction. This action on the outer fragment further assists in correction of shortening.

clavicle along its long axis is accomplished. Skeletal transfixion of the outer end of the clavicle or the acromion process, a means of obtaining traction used by some surgeons, will rarely be necessary when adequate sustained elevation of the shoulder is available.

Optimal treatment requires (1) anatomical reduction; (2) efficient and painless immobilization; (3) immediate ambulation; and (4) relatively free use of both arms. Since elevation provides the principal mechanism whereby the fracture can be reduced and held, the problem resolves itself chiefly into a means of securing and maintaining proper elevation.

SUSPENSION-ELEVATION

Obviously, the bony shoulder girdle is normally elevated by a lifting rather than a pushing mechanism. Contraction of the sternocleidomastoid,

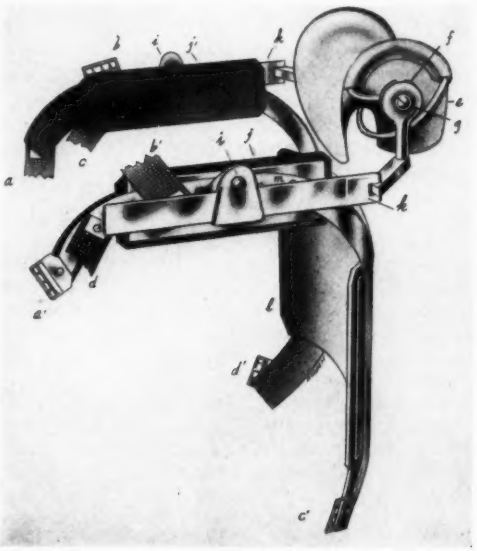


Fig. 5

Fig. 5. Suspension-hammock clavicle splint. *a* and *a'*, Strap under well shoulder. *b* and *b'*, Strap over well shoulder. *c* and *c'*, *d* and *d'*, Straps crossing around lateral body wall. *e*, Rubber axillary hammock. *f*, Joint at shoulder where hammock attaches to frame of splint. *g*, Bolt at shoulder adjustment. *i*, Sternoclavicular adjustment which controls sliding bars. *j* and *j'*, Anterior and posterior chest plates padded with sponge rubber. *k* and *k'*, Anterior and posterior bars. *l*, Lateral body plate. The sliding bars, *k-k'*, control the position of the hammock. By elevating them the shoulder is elevated; by sliding them both laterally the shoulder is displaced outward; by sliding the anterior bar laterally and bringing the posterior bar medially, the shoulder is displaced backward. The splint is made in 3 sizes: child, medium, and large. Since both sides are identical, it is completely reversible and fits either side of the body without a single change, yet operates at all times on anatomical centers.

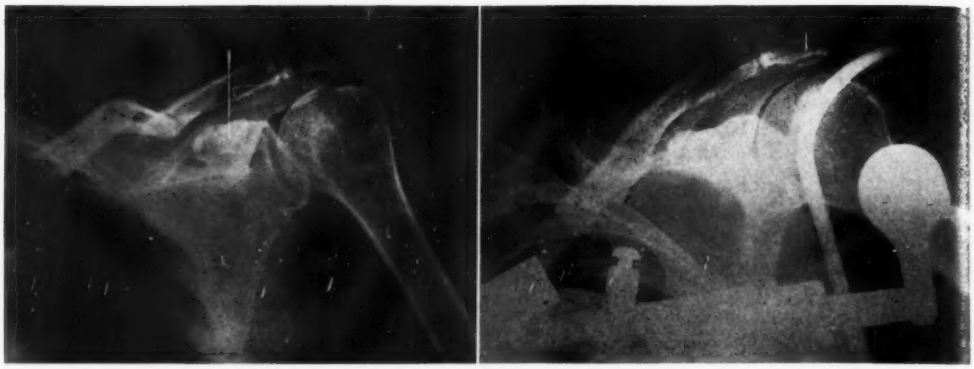


Fig. 6. Mrs. N. G. a, left. Comminuted fracture through middle third of the left clavicle in a middle-aged woman. Fractures of the clavicle in adults are frequently comminuted with one or more loose fragments. b, Same patient as in Figure 6a following immediate reduction in suspension-hammock splint. The outer fragment and shoulder have been elevated into a position producing correct alinement. Control and fixation of the shoulder from the anatomical center, or the sternoclavicular joint, makes possible this type of reduction.

trapezius, levator scapulæ, and rhomboid minor muscles shortens the distance between the upper spine and shoulder. With the head and spine fixed, these muscles lift the shoulder upward. The physiologically correct means for securing shoulder elevation in clavicular fractures should utilize this same lifting mechanism. With the patient in bed, suspension-elevation can be accomplished by adhesive or flannel traction on the shoulder. In the past there has been no means whereby the same principles could be utilized and still permit ambulation. This can be accomplished, however, by suspending a resilient, compressible hammock under the axilla and elevating this hammock. Such suspension-elevation, to conform to anatomical lines, must be functionally adjustable from centers over the clavicular joints.

SUSPENSION-HAMMOCK SPLINT

To apply the principle of suspension-elevation successfully, we use a new type of clavicular splint. With this appliance it is possible to treat fractures of the clavicle along correct anatomical and physiological lines, at the same time allowing the patient to be up and about wearing usual clothing and retaining use of both arms. Convalescence is painless; the splint is comfortable. Many patients return to work a few days after injury; in fact, skilled and professional workers have continued work regularly with splint in place.

The splint (Fig. 5) consists of (1) a body frame or base and (2) a rubber suspension axillary hammock. The base fits comfortably and snugly to the patient, and from the anterior and posterior chest plates two sliding bars extend laterally supporting the axillary hammock. These bars are completely adjustable from a point over the sternoclavicular joint, hence correct replacement of the shoulder to any desired position is accomplished along the normal axis. The design of the base is such that the weight of the injured shoulder girdle is largely borne by the well shoulder and upper relatively immobile portion of the chest and back. In this way undue constriction to respiratory movement is avoided and the support is more constant and stable than that derived from lower down on the chest or from the pelvis.

The hammock is molded to conform to the axilla. Its special rubber composition distributes the weight over a large surface, thus avoiding axillary compression. Thus not only adequate elevation, so essential for immobilization, can be obtained and held, but also both backward and lateral replacement is available when needed.

APPLICATION OF THE SPLINT

No anesthesia is necessary in most cases. However, if the patient is unduly apprehensive or suffering a good deal of pain, a local injection of 2 per cent procaine at the fracture site allows painless placement of the splint and reduction of the fracture. Being superficial, the fracture site is easily located, and injection of as little as 3 to 5 cubic centimeters of procaine into the hematoma will usually allow painless manipulation.

With the patient sitting or standing, the splint, hammock attached, is fitted to the patient with the adjustment on the anterior chest plate lying

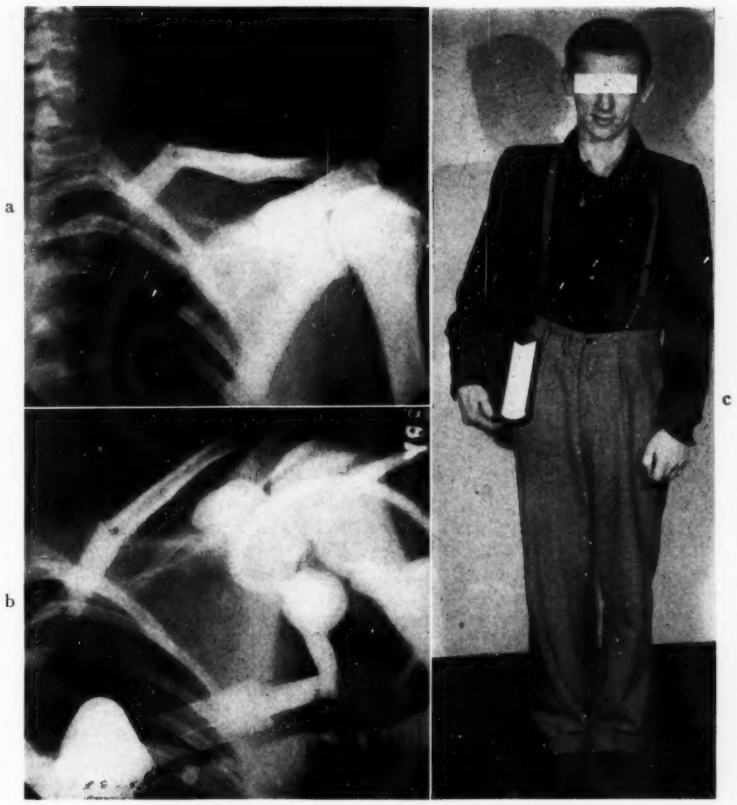


Fig. 7. Mr. G. D. a, Transverse fracture through the middle third of the right clavicle in an adolescent boy. This type of fracture, usually displaced, is commonly seen in children and adolescents. b, Reduced under local anesthesia with suspension-hammock splint. c, Three days after reduction. Normal clothing is comfortably worn. The reduced position of fragments is maintained despite comparatively free use of arm. Elevation and slight posterior position of shoulder on injured side are clearly seen.

near the sternoclavicular joint. It is well to pad all parts of the splint contacting the skin, preferably with cotton-gauze pads. The 4 straps attached to the body base hold it firmly in place, 1 strap going over the well shoulder, 1 under the well arm and the 2 long straps crossing loosely around the body to attach to the extensions below the lateral body plate. The well shoulder and axillary straps are really the fundamental fixateurs. The 2 long straps merely assist in stabilizing the lateral body plate, should the appliance be converted into an airplane splint. Reduction is accomplished by loosening the two bolts controlling the sliding bars and placing shoulder in correct position.

As was stated, elevation will be the basic maneuver. Sufficient elevation should be obtained. yet it is possible to overelevate the shoulder. Before any patient wearing the splint is discharged, positive roentgenographic and physical evidence of bony contact must be obtained. If necessary to place the shoulder posteriorly, the anterior sliding bar is lengthened and the posterior bar shortened. Lateral replacement is obtained by sliding both bars outward. As the arm falls outward over the hammock, the pull of its weight will further assist in correcting overriding.

With the desired position attained, the adjustment bolts are firmly fixed and the patient is free to wear regular clothing, continue normal activity, and enjoy the use of the arm. Because the weight

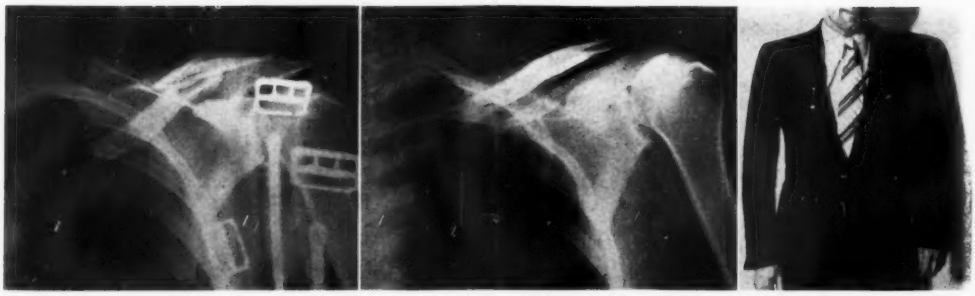


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Fig. 8. Mr. F. K. a, Spiral fracture of the outer third of the left clavicle in a young, male adult. This is a third type of clavicular fracture commonly encountered. The patient is wearing a crutch splint of the standard type. Despite the fact that the splint was fitted but the day before, the displacement has reappeared. b, End-result of fracture shown in Figure 8 a. Patient was placed in a suspension-hammock splint and the shoulder adequately controlled. Note the satisfactory alinement with restoration of length. Although the type of fracture determines to a certain degree the amount of callus thrown out, correct reposition of fragments maintained throughout healing minimizes excessive callus production and subsequent deformity. c, Patient wearing the suspension-hammock splint 3 weeks after injury. In many cases patients are able to return to certain types of work during convalescence.

of the shoulder is transmitted through the splint to the body along the anatomical lines, there is no tendency for the splint to slide downward, hence the position is not lost. Adjustments, therefore, are infrequently needed.

The splint is left in place continuously for 3 weeks or more as indicated by type of fracture and rate of healing. Check-up roentgenograms are taken at intervals and any adjustments made.

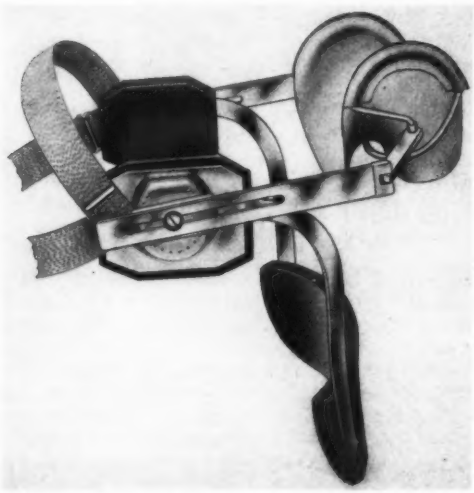

Fig. 9. A modified splint, economically designed, to treat fractures of the clavicle alone. The fundamental principle of suspension-elevation is retained with controlled adjustment anatomically centered over the sternoclavicular joint. The low construction cost permits its use in large charity clinics.

The immobilizing treatment of the fractured clavicle is the same whether it be comminuted, spiral, transverse, or compound. A greenstick fracture with marked angulation calls first for manual correction. The technique, moreover, permits alterations and additions to fit the case.

If skeletal transfixion of the outer fragment is desired, the splint affords an excellent means of both traction and countertraction, the transfixion being fastened to rods supporting the hammock.

Burgess arm attachments can be used to convert the clavicle splint into a completely adjustable airplane splint for the treatment of scapular and arm injuries as well as fractures of the clavicle, thus retaining and utilizing the physiological principles in ambulatory treatment of practically all pathology in the shoulder area.

Specifically, we use the base of this splint with attachments for (1) fractures of clavicle; (2) acromioclavicular dislocations; (3) fractures of scapula; (4) fracture dislocations of shoulder; (5) fractures of upper end of humerus; and (6) arthritis, periarthritis, and soft tissue injuries in shoulder area. In the rare non-union of the clavicle that demands operative treatment, the splint can be used after operation, since internal fixation alone is usually insufficient.

Recapitulating the steps in reduction, they are as follows: (1) Select suitable size splint (child, medium, large); (2) pad and fit splint to patient; (3) reduce fracture, this being accomplished largely through elevation of shoulder in normal sagittal plane; and (4) check position with x-ray.

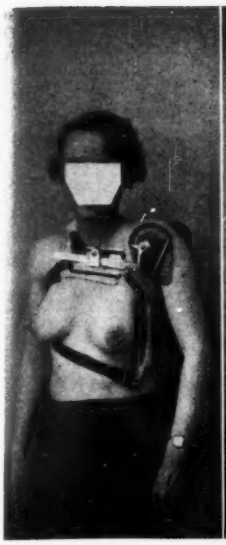

Fig. 10

Fig. 11

Fig. 12

Fig. 13

Fig. 10. Miss F. B. Fracture outer third of the left clavicle. Good bony union without deformity despite fact patient returned to work with splint on as a saxophonist in a dance orchestra. Observe compactness of splint, freedom of breasts, lower chest and arms, and elevation of shoulder. The ease of obtaining and maintaining elevation by this method necessitates a caution against overelevation.

Fig. 11. Child size splint. Since only the molded, compressible rubber hammock supports the axilla, elevation of the shoulder is well tolerated. Although unable to loosen, the hammock rocks freely, thus conforming to axillary contour at all times.

Fig. 12. Mr. A. L. Compression fracture of the first lumbar vertebra and comminuted fracture of the outer third of the left clavicle. A hyperextension plaster jacket was applied, after which a suspension-hammock splint was placed on the plaster. The splint is an earlier model. When his general condition permitted, patient was ambulatory, wore usual clothing, and returned home.

Fig. 13. Mr. R. H. Left acromioclavicular dislocation 3 days after injury. Patient is wearing the regular suspension-hammock clavicle splint with a strap over the injured clavicle to hold it firmly down in normal position. This case was immobilized as illustrated in Figure 14, but many of the complete dislocations are better controlled with the arm in wide abduction (Fig. 15). The suitcase is empty.

MISTAKES IN TREATMENT

This method of treatment is not foolproof. The physician must treat each case with a clear-cut understanding of the exact mechanical objective desired. Hurried reductions and neglected aftercare have no place in the treatment. Mistakes occasionally seen are: (1) use of wrong size splint; (2) improper placing of the splint; (3) inadequate padding under plates and straps; (4) overelevation of the shoulder—fracture ends must contact at all times; (5) attempt to push the shoulder too far lateralward—surprisingly little if any lateral push is necessary; (6) neglect of patient in reporting frequently for examination; (7) failure to take repeated check-up roentgenograms; and (8) removal of splint before there is good bony union.

A disadvantage with this method is the need of special equipment. Despite the achievement of superior results and the satisfaction of having an appreciative patient, the added expense will tend to limit the field of usefulness of any treatment requiring individual apparatus. Faced with this problem, we have designed an inexpensive, simple modification of the original splint to fulfill accurately all the requirements of suspension-elevation, yet modest enough in construction cost to be used on clinic and charity hospital cases (Fig. 9).

ADVANTAGES

With this new approach to treatment, fractures of the clavicle can be both accurately reduced and comfortably immobilized with a minimum of time loss or expense to either patient or physician. Because the principle of suspension-elevation controlled from the sternoclavicular joint is fundamentally correct, maximum results can be expected. Sustained reduction, unavailable with most standard ambulant methods, is a significant feature of this treatment. The patient enjoys immediate full ambulation, comparatively free

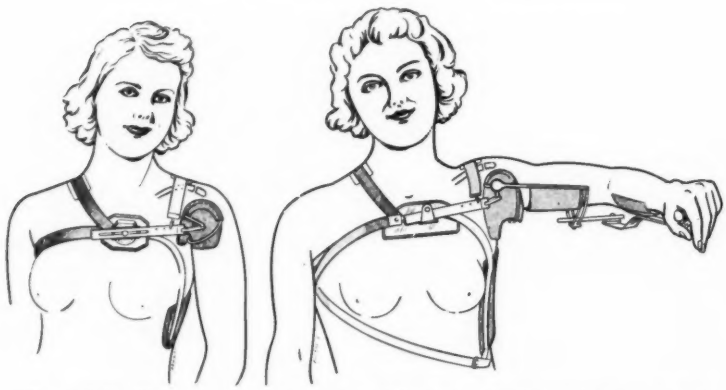

Fig. 14, left. Illustrating the strap over the injured shoulder for certain cases of fractures of the clavicle, particularly useful with fractures in the outer third or where a loose central fragment is present. The ends of the strap are fixed by hooks to appropriately located holes drilled through the transverse lever arms, front and back. A thick pad fits under the strap at the point of contact with the clavicle.

Fig. 15. Certain fractures of the clavicle are best treated by suspension-elevation with the arm in abduction, while occasionally the very difficult case calls for continuous traction. In this instance, the rubber axillary hammock supplies both the countertraction and the suspension elevation. Conversion of the clavicle splint into an airplane splint is accomplished through an arm attachment. In addition to using this Burgess airplane splint for difficult cases of fractures of the clavicle, it provides a treatment for scapular fractures, fractures of the upper humerus and fracture-dislocations of the shoulder.

use of arm, no constriction to breathing, usual clothing, painless convalescence, and a satisfactory end-result.

When it is necessary to confine patients to bed, due to the presence of multiple injuries or other complicating factors, the advantages of treatment by suspension-elevation may be obtained by placing adhesive traction on the arm with the arm abducted to 145 degrees. Only a few pounds' traction will be necessary, based on the roentgenograms and the position of the fragments. The head of the bed may be elevated to supply countertraction, a fracture board is placed under the bed, and a small pillow may be placed between the shoulders.

SUMMARY

Although generally considered to be a simple and rather unimportant fracture, a check-up on the end-results of any consecutive series of cases will quickly evidence the failure of usual ambulatory methods to immobilize properly fractures of the clavicle. In adults, among whom the fracture is becoming increasingly frequent, the deformities persist and an unsightly and unsatisfactory end-result follows.

A brief review of the functional anatomy of the shoulder area as obtained by living fluoroscopic studies reveals the primary importance of the sternoclavicular joint as a functional center for shoulder-girdle motion. The surprising degree of motion at this joint is not generally known, yet has an important bearing on the means of immobilization of fractures of the clavicle.

A functional and anatomical approach to the treatment of clavicular fractures is presented whereby the principle of suspension-elevation is utilized. A new ambulatory treatment is advanced, incorporating this principle and allowing controlled adjustment of the fracture from points over the sternoclavicular and shoulder joints. Throughout convalescence patient is ambulatory, comfortable, permitted usual clothing, and in many cases able to return to certain types of work.

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CALIBRATED INTERMEDIATE SKIN GRAFTS

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THIS paper has a two-fold purpose: first to emphasize particularly the advantages of a type of skin graft which it has not been possible, for the writer at least, to cut previously, namely, a skin graft cut at a predetermined level in the last quarter of the thickness of the skin; second, to present a new method of cutting skin grafts. This method has made the use of a truly deep intermediate graft not only possible but in addition allows one to cut any type of sheet skin graft proficiently and at a uniform depth.

PERTINENT PROPERTIES OF THIN AND THICK SKIN GRAFTS

Using my own cases for material for the purpose of orientation, it would seem pertinent to review briefly certain properties of the 2 types of skin grafts which in my work have proved the most useful, namely, the thin or superficial intermediate graft (2, 4, 5) and the full thickness skin graft (1, 3, 4, 5, 7). On checking the skin graft operations I have performed up to 1938, I found that there were 386 of the thin or superficial intermediate type and 369 of the so called full thickness variety. As my experience grew, however, I found that a decreasing percentage of the full thickness skin grafts were being applied.

The results in so far as contracture, appearance, and percentage of "take" are concerned following skin grafting operations in general are largely dependent upon the relative thinness or thickness of the grafts. The underlying base on which a skin graft is placed tends to contract in direct proportion to the thinness of the graft aside from certain anatomical factors which may be such that a base is formed which prevents contracture (Fig. 1). The final appearance tends away from that of normal skin more or less proportionate to the relative thinness of the graft. That is, a full thickness graft most nearly approaches that of normal skin in appearance (Fig. 2). While a thin skin graft will "take" under proper conditions in nearly 95 per cent of instances on a granulating surface and even in a higher percentage on a clean raw surface (Figs. 3 and 4), only on clean raw surfaces is it wise to attempt to get a "take" with a full thickness skin graft, and even then on concave and uneven surfaces one runs from a 20 to 30 per cent chance of not being able to secure an adequate "take."

Thin or superficial intermediate skin grafts of large size may be obtained easily with relatively little damage to the area from which they are cut. If correctly used on surfaces where weight bearing or repeated trauma are not factors, such a graft may give sufficient protection. As a general rule, the operation can be done quickly. The donor area heals rapidly from the base and one can retake another graft from the newly formed skin after 3 or 4 weeks if necessary. The postoperative dressing period is usually short—from 10 days to 2 weeks. Thus, the correct application of the thinner type of graft sometimes offers a method which in 1 or 2 operations will correct functionally a considerable contractural deformity, or adequately cover a raw area of considerable size. The opposite side of the story concerning the thinner graft is that the appearance is not always satisfactory; contraction tends toward maximum and protection may not be sufficient.

The main advantage of the full thickness skin graft, if one can obtain a perfect "take" of the graft, is that the final result both as to function

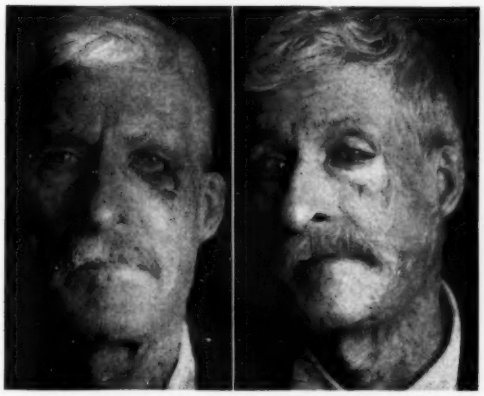


Fig. 1. Ectropion of the eye before operation and 3 months after application of the skin graft. These photographs illustrate the amount a thin skin graft will contract unless the base is firm. This graft was 2¼ by 3½ inches when it was applied over a stent, and still after contracting the area covered by the graft was only 1½ by 1½ inches.

Delivered before the Western Surgical Association, Denver, Colorado, December 2, 1938.

From the Department of Surgery of the University of Kansas School of Medicine.

Fig. 2. This photograph shows how near a full thickness skin graft will assume the appearance of normal skin after it is transplanted. This girl had a large "port wine stain" covering one-half of her face which had been overirradiated causing itching, scaliness, and telangiectasis. The whole area was excised and a full thickness skin graft was applied. In this particular case we obtained a good "take" of the graft in spite of the fact that a full thickness graft "takes" in only about 20 per cent of the cases. At the present time we would correct such a condition by means of a deep intermediate skin graft.

Fig. 3. This is an example, before and 3 months after operation, of a rather severe contracture of the axilla which was corrected by means of cross-cutting, removing the scar, and applying a skin graft as thick as could be cut with the large knife.

and appearance is the best that can be obtained (Fig. 5). However, some superficial loss from blistering and deep loss from focal areas of necrosis is often a feature. Depending upon the extent and depth of the damage, the final appearance and alleviation of the functional disability become endangered. A full thickness skin graft will give good protection and tends to develop fairly plentiful subcutaneous tissue. Characteristically, especially if there be considerable blistering and areas of focal necrosis, the postoperative dressing period is prolonged over an interval of from 3 to 5 weeks. Finally, it is necessary to draw together and to suture the skin edges of the defect which has been produced by the removal of a full thickness skin graft.

SKIN FLAPS

Although somewhat beside the point, a word concerning the uses of skin flaps can hardly be omitted, as their merits and demerits must as a rule be contrasted with those of skin grafts when the method of reconstruction is selected. For the

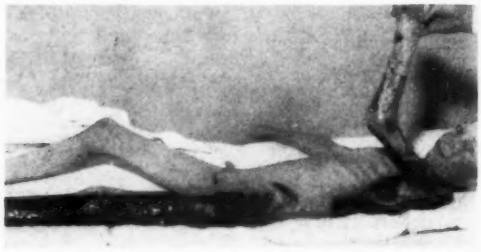
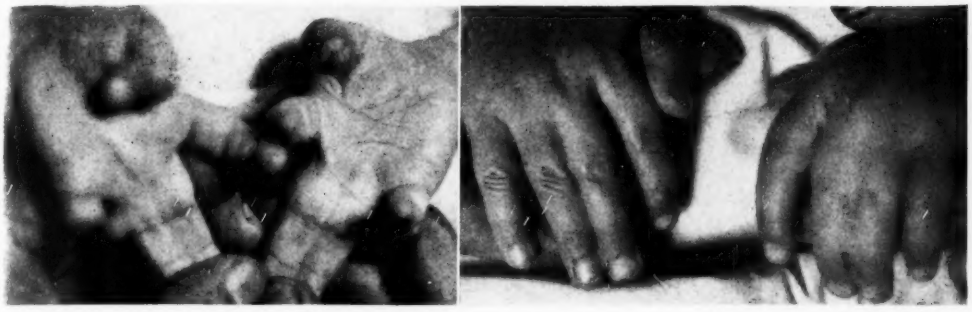


Fig. 4. Method of covering a large raw area with thin skin grafts following a severe burn. At such a time one is only attempting to resurface the granulating area. At a future date the contracture may be cross-cut and a thicker graft applied. Photographs show the boy 3 weeks after he was burned, above, and at the time he was allowed to leave the hospital, left. For a number of weeks he was very sick with a high fever and was comatose. He had a rather severe nephritis which gradually cleared up. Patient was advised to return in 2 or 3 months after his general health had improved, for correction of a moderate amount of contracture of his legs and arms.



a b

c

Fig. 5. Photographs showing complete webbing between the second and third fingers of both hands. a, Ventral view; b, dorsal view. c, Photograph of the fingers about 2 months after correction by the application of full thickness skin grafts between the fingers. This webbing was corrected in one operation by this method.

building of organs a skin flap has no competition when requiring thickness, for filling a depression in the soft tissues, for building a part requiring 2 soft, pliable, epithelial surfaces and some thickness, and as a direct covering for tendons, bones and cartilages, especially if considerable trauma must be withstood (Fig. 6, a, b, c, and d). But when a simple surface epithelial covering is the only indication and the blood supply of the base is sufficient, I have as a rule selected the appropriate skin graft believing that it will give the most acceptable result.

CALIBRATED INTERMEDIATE SKIN GRAFTS

About a decade ago Blair and Brown, in an effort to combine the advantageous qualities of the thin razor graft with that of the full thickness graft, presented a skin graft alleged to transect the uppermost 25 to 75 per cent of the skin. This graft they designated as the "split" skin graft (1) and represented a definite step forward. However, I was never able to cut the graft without considerable variation as to thickness and size.

It occurred to me after observing the advantages of the "split" graft that if one could cut a uniform graft at a level below that suggested by Blair and Brown and yet keep above the lowermost limits of the corium, such a graft would have desirable qualities not yet obtainable. The ideal graft for many purposes should be directed toward getting a graft of such thinness as to assure successful transplantation, leave the donor site capable of spontaneous regeneration, and yet of such thickness as to afford adequate protection, minimum contraction, and at the same time match the surrounding skin relatively satisfactorily in so far as texture and color are concerned. Furthermore, I was of the opinion that if one could vary the thickness of the graft at will, depending upon the region to which it was to be applied and the lesion which it aimed to correct, it might prove desirable for various lesions in different locations to lean toward thinness or thickness as indicated. And again, it was my belief that according to the age of the patient and the particular region from which the skin was to be removed, a variation in thickness might be desirable, as it is well known that the skin of children is thinner than that of adults, and that the skin in certain regions varies, as for instance, the skin on the inner thigh of a woman is thinner than that of the outer thigh. Moreover, for certain lesions it was evident that if one could remove the skin from any area of the body such as the chest, the back, or over the ribs, certain areas could be resurfaced in a way not possible by the use of the methods commonly practiced.

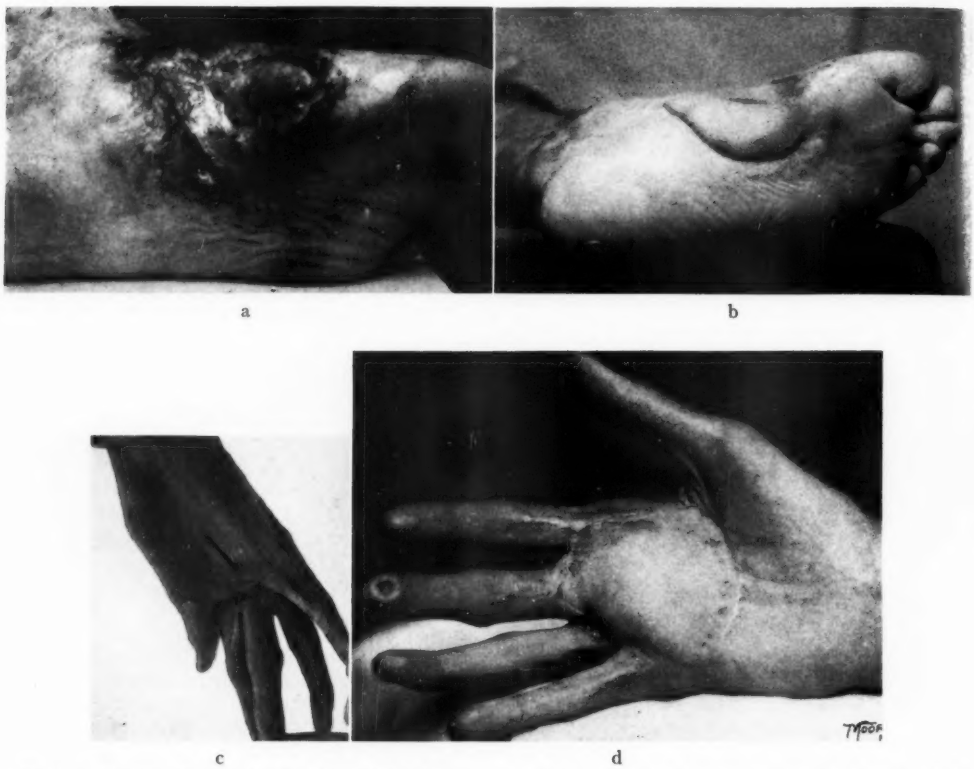


Fig. 6. a, Photograph of an electrical burn of the plantar surface of the foot which destroyed the skin and subcutaneous tissue over the internal metatarsal bone, about one-half of the bottom of the foot, most of the inner portion of the foot, and one-half of the external lengthwise half of the metatarsal bone of the foot. In this case a flap from the opposite leg was transplanted over the area to give a subcutaneous pad and so that the foot would stand the trauma to which it would be subjected. b, Photograph of the foot 2 months after correction. c, The palm of the hand was torn off in the cog wheels of a printing press. When the hand was opened the destruction of the soft tissues was such that the flexor tendons of the fingers were laid bare. It was, therefore, decided to use a skin flap from the abdomen to cover the bare tendons. Although the skin flap was a little thick the function of the hand is normal. d, Photograph showing the result after correction.

But to cut a graft such as I had in mind entailed mechanical problems. The ordinary skin graft knife was found to be inadequate. Aside from the difficulties encountered in its application in relation to anatomical location, age, and sex of patient, the most formidable objection was the inability to cut a uniform sheet of skin at a predetermined level with any mechanical precision.

THE DERMATOME

With these ideas in mind it occurred to me that if one could draw the skin to a smooth surface and hold it in some manner, it could be cut in a sheet of uniform thickness and of a thickness previously decided upon, by passing the knife through the skin at a definite distance from the surface; in other words, truly an accurately calibrated dermatome.

In 1930, I carried this conception to a mechanical engineer and enlisted his aid to see if I could overcome the mechanical difficulties of the problem. From 1930 to 1937 in a more or less desultory fashion several different mechanisms were discussed, constructed, tried out, and discarded as not being workable or practical. Finally, fastening the skin to a smooth surface with cement or adhesive so that the skin would be held firmly to a longitudinally level surface was tried.

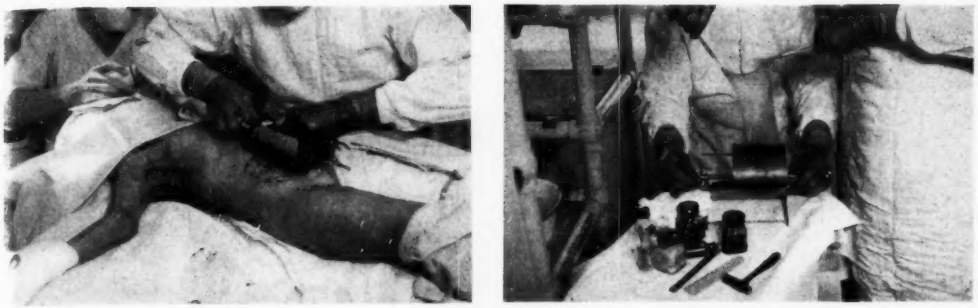


Fig. 7

Fig. 7. Adhesive cement is applied to both the drum and the skin. The photograph shows the machine working along cutting the skin from the abdomen in a perfect sheet. This skin graft is to be used to correct the axillary contracture shown in the photograph. In the second photograph, the sheet of skin is being pulled away from the drum with hemostats. It will be noted that the sheet is the same size as the drum and that it is a perfect rectangular shape of uniform thickness.

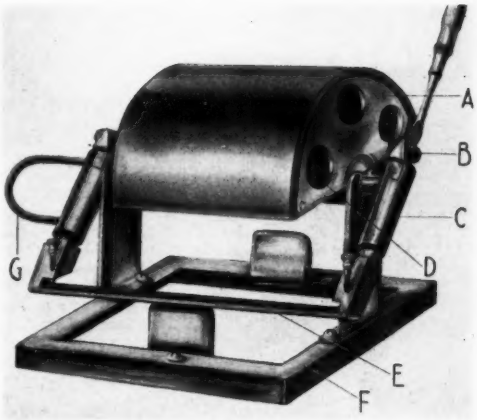


Fig. 8

Fig. 8. The dermatome standing on its rack. *A*, Support of drum; *B*, screw calibrated to .002 of an inch for each line on the head of the screw. The screw may be turned with a screw driver or with the thumb and forefinger. *C*, A tube with a round shaft inside into which the calibrating screw turns which raises *E*, the holder for the knife blade. A similar screw is on the opposite side with a duplicate of the same mechanism so that the knife blade may be raised or lowered at each side. The knife blade is drawn to the drum in the zero position and moved away from the drum by the double calibrating screws to determine the thickness of the graft to be cut. This provision is necessary but one has to reset the knife after each honing or grinding of the knife blade as this changes the distance of the knife blade from the drum. *G* is the handle by which the shaft is worked backward and forward by hand as shown in Figure 7. *D* is the knurled handle which is held in the opposite hand to rotate the drum as the knife holder or knife is turned around the drum. *F* is the base of the rack on which the dermatome rests when placing the adhesive on the drum, when placing the knife blade in position, or when the skin is being pulled away from the drum.

The dermatome is essentially a drum-like skin holder with a shaft passing through a hand holder which is the means of rotating the drum on the shaft and permits reciprocation of the shaft relative thereto, with a knife blade held by a supporting frame passed through spaced bearings to support the shaft. In the arms of the knife frame is a calibrating mechanism so that the distance of the knife blade can be set away from the drum at a predetermined distance. The principle of the dermatome is that the skin surface of the determined skin graft is held in contact with the drum while a knife blade transects the determined graft at a fixed distance from the drum thereby severing the graft from its bed at a uniform level throughout.

A mechanism consisting principally of a drum with a movable knife fixed at a definite distance from the drum was constructed. It was found that it was possible with the greatest facility and ease to remove a sheet of skin as large as the drum, or 4½ by 8 inches (Fig. 7) or smaller, to cut it absolutely uniform in thickness, and that the thickness could be varied as described by turning a calibrating mechanism which varied the distance of the knife from the drum in a predetermined fashion. Furthermore, it was found that the graft could be cut to pattern, if one wished, by nullifying the adhesive properties of the cement by painting out the area not to be removed with a solution of talc and ether. This solution prevents adherence of the skin to the drum. During the summer of 1938 the final model was worked out which, although embodying the fundamental idea of bringing the skin to a smooth surface, contained several very definite improvements which have greatly facilitated the use of the machine (Fig. 8).

Since the perfection of the dermatome in 1938 I have had occasion to employ 83 calibrated

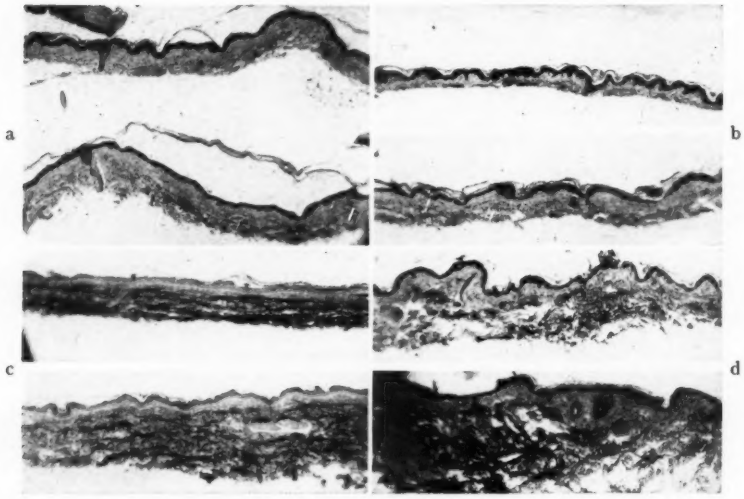


Fig. 9. a and b, Sections of Thiersch skin grafts. c and d, Sections of split skin grafts showing variation in thickness. ×16.

a, Thiersch graft cut from outer thigh adult male about .010 of an inch in thickness (.25 millimeter). b, Upper section: Thiersch graft cut from outer thigh of male, age 8 years, about .007 of an inch in thickness (.18 millimeter). Lower section: Thiersch graft cut from outer thigh of male, about .010 of an inch in thickness (.25 millimeter). c, Split graft cut from outer thigh of adult male shows variation from .010 of an inch (upper) (.25 millimeter) to .014 of an inch (lower) (.46 millimeter) in thickness; same graft. d, Split graft cut from outer thigh of adult male shows variation from .010 of an inch (.25 millimeter) to .018 of an inch (.46 millimeter) in thickness; same graft.

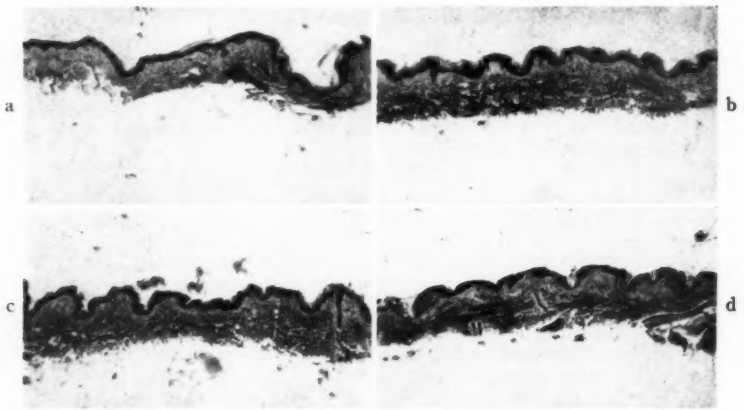


Fig. 10. Sections of typical "split" skin grafts. ×16.

a, Split skin graft from outer thigh of an adult male; thickness about .012 of an inch (.3 millimeter) at maximum. b, Split skin graft cut from outer thigh of boy age 9 years; thickness about .013 of an inch (.33 millimeter) to .014 of an inch (.36 millimeter). c, Split skin graft cut from inner thigh of a fat woman; thickness about .013 of an inch (.33 millimeter) to .014 of an inch (.36 millimeter) at maximum. d, Split skin graft from outer thigh of young adult male; thickness about .013 of an inch (.33 millimeter) to .014 of an inch (.36 millimeter) at maximum.

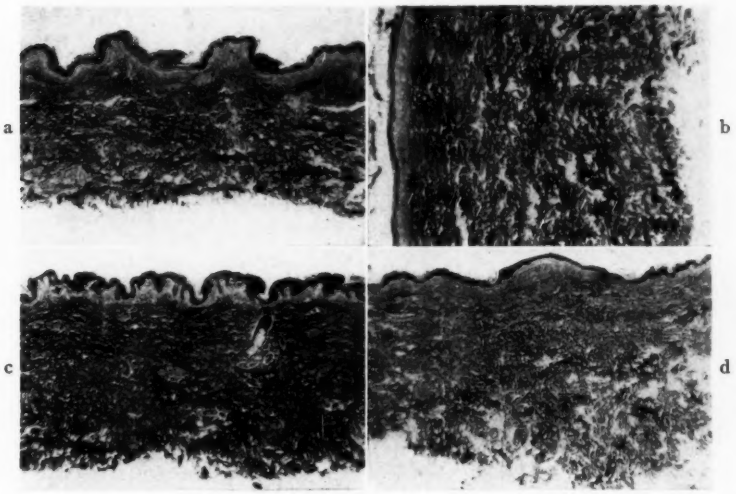


Fig. 11. Sections of full thickness skin grafts cut with scalpel showing variation in thickness. ×16.

a, Full thickness skin graft cut with scalpel from the abdomen of an adult male; thickness about .032 of an inch (.81 millimeter). b, Full thickness skin graft cut with scalpel from abdomen of an adult male about .040 of an inch (1.01 millimeter) in thickness. c, Full thickness skin graft cut with a scalpel from the abdomen of male child age 8 years; about .034 of an inch (.86 millimeter) in thickness. d, Full thickness skin graft cut with scalpel from abdomen of an adult male from .028 of an inch (.71 millimeter) to .034 of an inch (.86 millimeter) in thickness.

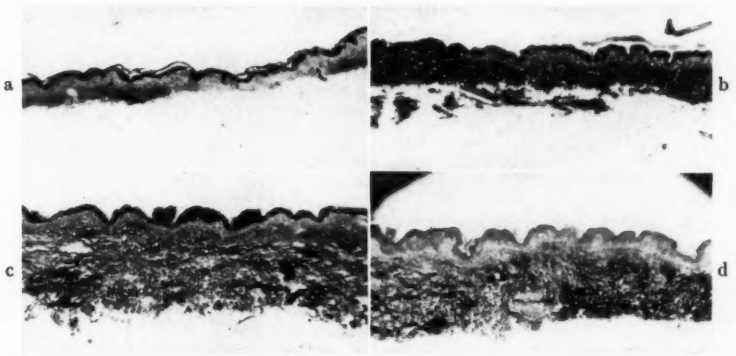


Fig. 12. Sections of thin and moderately thick calibrated skin grafts. ×16.

a, Male adult graft cut from abdomen about .010 of an inch (.25 millimeter) in thickness used to cover a granulating area. A good "take." b, Male adult graft cut from abdomen about .012 of an inch (.3 millimeter) in thickness used to cover a granulating area. A good "take." c, Male adult graft cut from abdomen about .018 to .020 of an inch (.46 to .5 millimeter) in thickness. Graft used to cover back of hand on clean raw surface. A perfect "take." No blistering. *d*, Male adult graft cut from outer thigh used to cover clean raw surface of dorsum and palm of both hands. .014 to .016 of an inch (.36 to .41 millimeter) in thickness. A good "take."

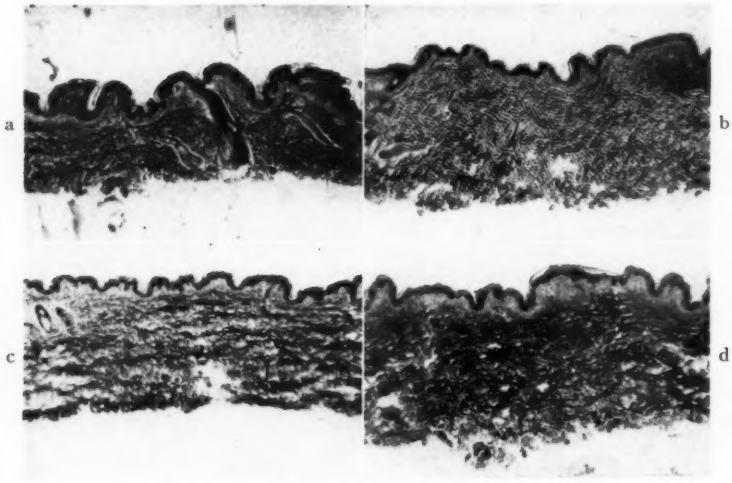


Fig. 13. Sections of thick calibrated skin grafts. ×16.
a, Graft cut from abdomen of boy 8 years old, about .020 of an inch (.5 millimeter) in thickness. b, Graft cut from abdomen of woman, age 60 years, pregnant previously; about .025 of an inch (.63 millimeter) in thickness. c, Graft of male age 14 years cut from abdomen; about .025 of an inch (.63 millimeter) in thickness. d, Graft of male age 65 years cut from thigh about .030 of an inch (.76 millimeter) in thickness.

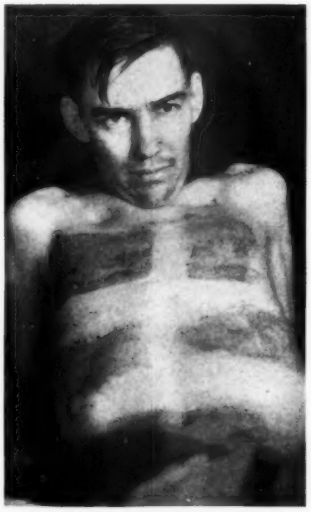


Fig. 14. Photograph of a granulating wound caused by a severe burn of the thighs, the knees, the upper legs, and popliteal spaces. The area involved both the extensor and the medial surfaces of both legs. To correct this area 2 operations were involved. In the first operation 744 square centimeters of skin were removed from the upper chest and anterior abdominal wall. This amount of skin covered about one half of the denuded area but we considered it about all he could stand at 1 operation. Three weeks later at a second operation 781 square centimeters of skin were removed from the same areas. By that time the subepithelial cells had caused regeneration. This allowed us to resurface his legs in 2 operations. This is the type of case in which formerly death resulted very often because it was impossible to cut enough skin from the back and abdomen to cover the lower extremities. This was particularly true if the patient was a baby or was emaciated. In the second photograph are shown the denuded areas about 10 days after the first operation.

Fig. 15. In this boy 2 operations were necessary. The granulating areas were first covered by thin calibrated skin grafts .012 of an inch in thickness and he was allowed to go home. After several months he came back with a certain amount of contracture in the popliteal space. At this time we had a healed field in which to work. After cross-cutting the scars, moderately thick calibrated skin grafts .018 of an inch in thickness were cut from the abdomen and applied over the denuded areas. The lateral and posterior views of leg show the functional result about 3 months after the second operation.

grafts. I found that I could cut skin at any predetermined, uniform depth and that it was possible to cut consistently at a depth of 75 to 95 per cent of the thickness of the skin, a deep intermediate graft which previously I had not been able to cut accurately.[1] It was also found that the dermatome was equally useful in cutting thinner grafts of almost any predetermined thickness, even as thin as .008 of an inch in thickness. The dermatone was found to be particularly useful in cutting various thicknesses of superficial intermediate skin grafts.

[1]When it is desired to be absolutely accurate in percentage depth, it is well to incise the skin vertical to its surface to judge the thickness of the skin before setting the calibrating mechanism of the dermatome.

Fig. 16. Example of obliterated eye socket which was grafted using a large stent about which a calibrated intermediate skin graft was draped .024 of an inch in thickness. Although the contracture is considerable in such cases room was left for an artificial eye. The photographs show the skin graft in socket and the result with an artificial eye in place.

VARYING THICKNESS

In an adult when the main indication was one of resurfacing a granulating area usually the graft was cut from .010 of an inch, or .25 millimeter to .014 of an inch, or .36 millimeter, in thickness (Figs. 9 to 13). When a clean raw surface was to be covered and the indication was one in which the appearance was a prime factor or it was essential to have minimal contracture, ordinarily the grafts were cut from .022 of an inch, or .56 millimeter, to .028 of an inch or .71 millimeter. It was found that at this thickness sufficient subepithelial elements remained in the base for early regeneration. When maximum appearance or minimum contracture were not such clear cut indications and the certainty of "take" seemed to rank relatively high in the balancing of the essential factors, the grafts usually were cut between .016 of an inch, or .41 millimeter, to .020 of an inch, or .5 millimeter in thickness. Observations were made on the thickness of the skin in varying locations and in both sexes.

In a woman sometimes after repeated pregnancies if the skin over the abdomen, the inner thigh, or the inner upper arm is removed at a level of .018 of an inch (.46 millimeter) to .020 of an inch (.5 millimeter) all of the subepithelial elements will be removed. The variation in the thickness of the skin in various locations varied in the male but not to as great an extent as in the female. Coincidently, while making these observations on the thickness of adult skin, children were being operated upon and their skin thickness was checked. In a young child 6 years of age for instance, if one cuts a graft from the abdomen of as little thick-

Fig. 17. Photograph of boy who had a marked fixation of his arm to his chest wall due to an old heavy scar. a, Anterior view. b, Posterior view. The scar and granulations were excised. The arm was hyperextended leaving a very large denuded area from the elbow to the lower rib region. Calibrated skin grafts of deep intermediate thickness were taken from both thighs and applied to the raw area. Four drums of skin were used. In this case the grafts were .018 of an inch in thickness. c and d, Show the result about 3 weeks later. e and f, Show the result 1 year after the grafts were applied.

ness as .014 of an inch (.36 millimeter) to .016 of an inch (.4 millimeter), he may remove all of the subepithelial elements of the skin and healing will be by secondary intention. When a calibrated graft is removed from a baby 2 or 3 months old to leave sufficient epithelial elements in the bed for regeneration, one can hardly cut the graft more than .010 of an inch (.25 millimeter) to .012 of an inch (.3 millimeter) in thickness. When the child is about 12 to 14 years of age one cannot cut lower than .016 of an inch (.41 millimeter) to .018 of an inch (.46 millimeter) in thickness.

COMPARISON OF SKIN CUT BY VARIOUS METHODS

Coincidently with the cutting of a calibrated skin graft, a Thiersch graft and a split graft cut

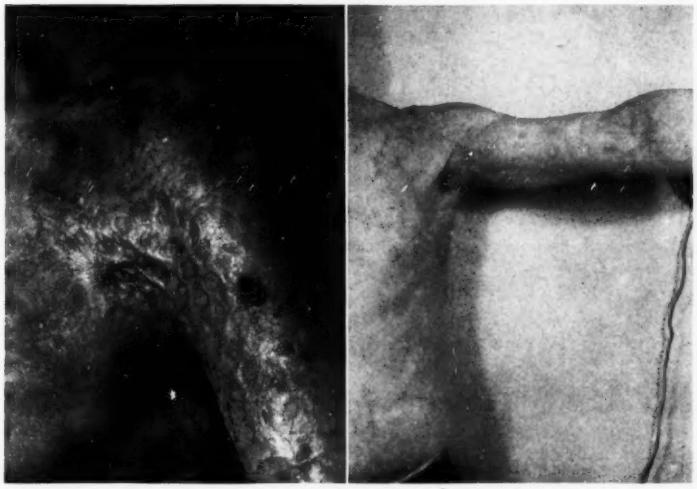


Fig. 18. Example of a patient who had a fixation of his arm to the chest. Pin point grafts had been applied by another surgeon. At the time the photograph was taken healing had occurred but he could not extend his arm. In this case the scar was cross-cut and a skin graft of deep intermediate thickness .024 of an inch was applied to the axilla. He also had a contracture in the elbow region which does not show in the first photograph but the area which was grafted shows in the final photograph, right, which was taken 4 months after the operation.

Fig. 19. Photograph of patient with marked cicatricial contracture of the lower mental region, the neck, the upper chest, the right axilla, and the right elbow region. Three operations were necessary to correct this deformity and deep intermediate skin grafts .018 of an inch in thickness were used to correct the contractures. At each operation good "takes" occurred but there was a certain amount of subsequent contracture. The photographs show patient before operative procedures were instituted and 4 months after the last operation.

Fig. 20. Photograph of patient who had a large marked scar on the leg and a cicatricial contracture of the popliteal space with a scar on the inner side of the malleolus which pulled the foot into a position of varus. After the scar was removed and the area split lengthwise of the leg to release the contracture 3 large skin grafts .024 of an inch in thickness were removed from the abdomen and thigh and were placed from the region of the os calcis to about 3 inches above the knee in the posterior region. The scar on the malleolus also was excised to correct the varus. The idea here was to open up all contractures and to resurface the popliteal space. This was done in one operation. The photographs show the scar and the result 1 year after skin grafts were applied. The burn had occurred 2 years before we saw him.

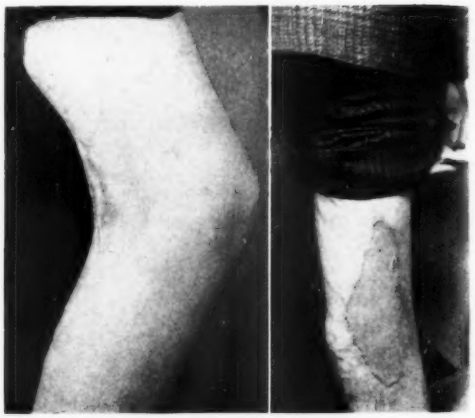


Fig. 21. Photograph of boy with cicatrix of the leg, for which deep intermediate skin grafts were applied. The second photograph shows patient 3 weeks after skin grafts were applied.

in the routine manner, usually from the thigh, and a full thickness graft cut with the scalpel were removed from each patient. About 100 sections were obtained from patients of various ages. These were carefully cross-sectioned at as nearly right angles to the skin surface as possible after fixation, and their relative thickness compared with the known thickness of the calibrated skin grafts.

CLASSIFICATION

From this microscopic study of skin grafts cut by all methods by the writer, a reclassification of sheet skin grafts into 4 types has been evolved: (1) Thiersch[1]; (2) superficial intermediate (Blair et al) 1/3 to 2/3 of the skin depth; (3) deep intermediate, 75 to 95 per cent of the skin depth; and (4) full thickness.

The following conclusions were reached: (1) The Thiersch graft is cut at a thickness of about .008 of an inch (.2 millimeter) to .010 of an inch (.25 millimeter) in thickness (Fig. 9). (2) The "split" graft or superficial intermediate skin graft, as cut with the large knife, is usually from .012 of an inch (.3 millimeter) to .020 of an inch (.5 millimeter) (Figs. 9 and 10). (3) The deep intermediate graft which is cut with the dermatome and may be predetermined is from .022 of an inch (.6 millimeter) to .030 of an inch (.76 millimeter) in thickness. (4) A full thickness skin graft in an adult according to our sections varies in thickness from about .032 of an inch (.8 millimeter) to .045 of an inch (1.14 millimeters) (Fig. 11).

Any and all of these grafts obviously can be cut more proficiently with the dermatome than by any previous method. These experiments were done solely to determine what we had been doing in the past.[2]

SUPERFICIAL INTERMEDIATE CALIBRATED SKIN GRAFTS AS CUT WITH THE DERMATOME

There is no essential difference between the superficial intermediate calibrated skin grafts as cut with the dermatome from those cut by other methods. No new factor is involved except that one may select a predetermined thickness and cut the graft with the dermatome at a uniform level which cannot be done by means of the large knife,

[1]Thiersch's original description of his graft as containing only the epithelial layer probably never was or cannot be cut. There is always some corium.

[2]Skin contracts quite markedly after it is cut due to the elastic fibers in the corium. These figures are for the skin before it contracts. After it contracts and is stained and placed on a microscopic slide it will measure nearly twice as great in thickness. For example, a section cut with the knife set at about .032 of an inch (.81 mm.) away from the drum will measure in width about .060 of an inch (1.5 mm.) on the slide. In the photomicrographs the skin was cross-cut as nearly at right angles as possible. A considerable number of each were taken, about 100 different sections in all. An average was struck to compensate for error on sectioning. The examples shown are more or less average and considered fairly typical. The photomicrographs were enlarged 22 times above the size of the tissue on the slide.

Fig. 22. Drawing of a severe burn of both legs. Granulating areas were still present after 18 months and there was no tendency to heal. In this case granulating areas were completely excised so that a clean scar base was present. Two large calibrated skin grafts taken, 1 from the abdomen and 1 from the thigh were applied to the clean raw base. The photograph shows the final result 6 months later. The man's skin is nearly normal in appearance and a fair subcutaneous tissue has developed beneath the skin. There is no tendency for the skin to break down.

and that a graft of very large size may be taken from locations not previously available. For instance, skin grafts have been obtained from the pectoral and scapular regions in markedly emaciated individuals, the lumbar region, the posterior gluteal region, relaxed pendulous abdomens and over the ribs if the patient is not too emaciated, all in regions in which the skin graft knife despite the utmost dexterity is of no great use. Therefore, the good advantages available to the surgeon when using this type of graft are mainly attributable directly to the dermatome.

Foremost, one cannot but be impressed by the area of skin that is available to one. This factor alone allows one to graft successfully a type of individual occasionally seen who in the past has been nearly hopeless, as for example, the type of patient with a large denuded surface covering both thighs and legs where most of the remaining skin is on the trunk (Figs. 14 and 15).

In a case of this type with both legs denuded, at the first operation 744 square centimeters of skin were removed from the abdomen and anterior chest in 6 large sheets. This covered about one-half of the denuded area. Three and a half weeks later at a second operation 781 square centimeters of skin were removed from the same areas previously used allowing a completion of the resurfacing. Several times as much skin as taken in this case has been removed from similar patients[1]. Because of the fact that one can obtain a uniform large sheet of skin to drape over a form or stent, a graft which is cut by the dermatome is particularly satisfactory when a cavity is to be grafted as in Figure 16 which shows a case of an obliterated eye socket.

On a baby one cannot cut by hand with a skin graft knife a graft of sufficient size to be very useful if one has a large defect to cover. With the dermatome a graft of large size may be taken from either the abdomen or the chest. It may be ex-

[1]A warning might be wise here. A blood transfusion may be necessary because of loss of blood serum when too much of the body surface is denuded. The same factors obtain when there is too much denudation following a burn.

Fig. 23. a, Basal cell epithelioma of the side of the forehead which had been unsuccessfully irradiated with a recurrence. This area was excised and intermediate skin grafts .026 of an inch in thickness removed from the abdomen were applied. b, Appearance 2 months later. c, This patient had a scar which had drawn her upper eyelid out of place and had destroyed her eyebrow. In this case a deep intermediate skin graft .026 of an inch in thickness was applied after the scar was excised. A full thickness skin graft was removed from the scalp to make her an eyebrow. d, Appearance of the graft and the eyebrows 1 year later.

tremely difficult or impossible to cut sufficient skin from available areas with the large skin graft knife and do much in the way of resurfacing when the individual is very emaciated, as may occur when one sees a severe burn a number of months after its occurrence. As a matter of fact, in our routine work practically all of our grafts are cut by the dermatome at the present time (Fig. 8). The ease, the accuracy, and the quickness of the method recommend the constant use of this mechanism.

THE DEEP INTERMEDIATE SKIN GRAFT

Our experience with the deep intermediate skin graft as cut with the dermatome indicates that by proper cutting, provided other factors such as proper fixation, tension, hemostasis, pressure, and a clean field are obtained, the chance of failure of "take" is nearly eliminated. Because the certainty of "take" is increased one can extend the magnitude of his reconstruction to limits not advisable previously. Difficult areas to graft with thick grafts such as the lateral cheek, the neck, and the axilla and dorsum of the hand become acceptable cases in which successful repair is to be expected and not just hoped for (Figs. 17, 18, 19, 20, 21 and 22).

The fact that this type of graft shows little blistering or areas of necrosis causes the final appearance to approach that of normal skin. (Fig. 23). Its appearance is as good as that of a full thickness graft after a perfect "take." These factors plus the fact that the donor area does not have to be sutured, as it heals in from 10 to 14 days (Fig. 24,), has caused us to cease using the full thickness skin graft except in babies where the amount of skin necessary is slight as in web fingers (Fig. 5).

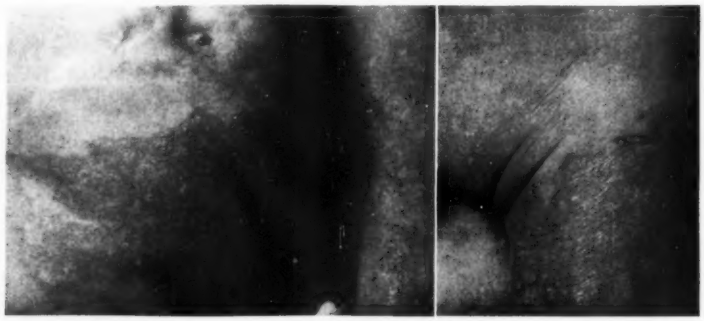


Fig. 24. Photographs of abdomen and thigh of the patient shown in Figure 18. This photograph was taken 3 weeks after the skin grafts had been removed. The grafts were .024 of an inch in thickness.

SUMMARY AND CONCLUSIONS

To recapitulate, the deep intermediate skin graft as cut with the dermatome is comparatively certain to "take." The new graft shows practically no blisters or local areas of necrosis. It may be cut to pattern if one desires. The ultimate contraction is reduced to a minimum. Good protection is offered. The appearance as a rule approaches that of normal skin. The donor area heals quickly. The postoperative period of care is relatively short. Finally, as a rule, the usual run of lesions may be corrected in one operation.

The properties of skin grafts in general are summarized. The development of the dermatome has removed many of the mechanical difficulties of cutting a skin graft of the needed size and correct thickness. Microscopic examination of the thickness of the average graft as cut by various methods suggests a more accurate reclassification as to thickness. It is now possible to use grafts in certain cases in which formerly a successful result was sometimes not possible to obtain.

A deep intermediate skin graft, which has advantages over the full thickness skin graft, cut at a level ordinarily not possible before the development of the dermatome is described.

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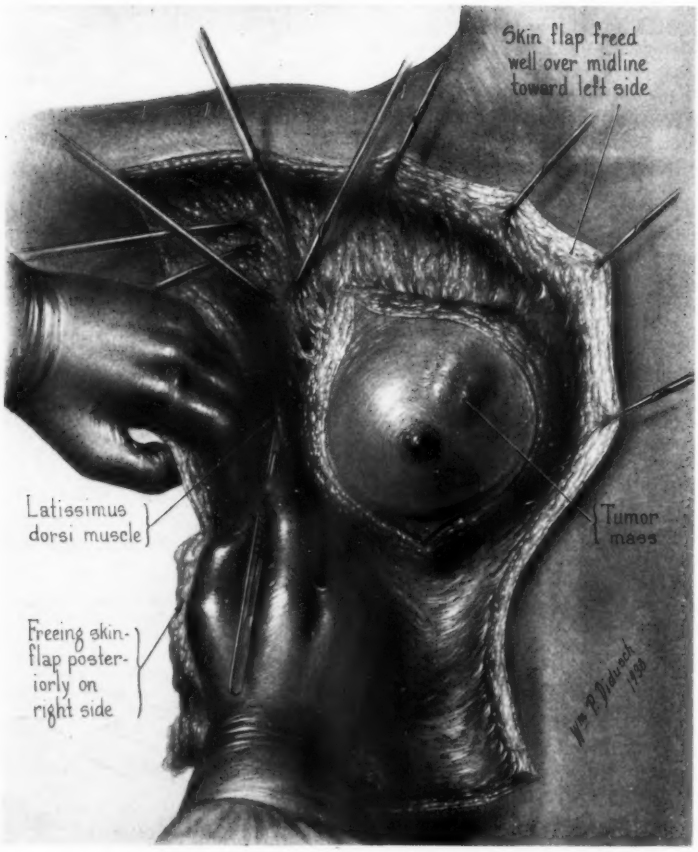
Skin flap freed well over midline toward left side
Latissimus dorsi muscle
Tumor mass
Freeing skin-flap posteriorly on right side

Fig. 3. Dissection of the skin flaps down to the latissimus dorsi.

A Method for the Prevention of Elephantiasis Chirurgica.—Elliott H. Hutchins.

A METHOD FOR THE PREVENTION OF ELEPHANTIASIS CHIRURGICA

ELLIOTT H. HUTCHINS, M.D., F.A.C.S., Baltimore, Maryland

ON October 7, 1931, my attention was called to a patient who presented an unusual picture. He was operated upon by me when he was two years of age for an infection of the ankle which had developed while he was playing in a field where his mother was picking beans. I had not seen him from that day until he appeared in my office, practically a grown man. He had an enormous swelling from the groin to the foot on the affected side. There were no visible scars about the groin and no induration suggesting scar tissue sufficient to block the lymphatics. He had a temperature and was rather ill; on admittance to the hospital he had a moderate degree of pain. The swelling was peculiar in that the skin was transparent, pitted on pressure, and the entire thigh and leg had the appearance of an acute edema. I was unable to determine what caused the swelling or why it subsided almost to the point of disappearing while he was under observation. While it apparently did not have any connection with his foot at the age of two, the infection may have produced scar tissue of a permanent type in the neighborhood of the glands in the groin, simulating rather closely that which occurs in the axilla following a breast amputation, but differing when the increased mobility of the tissue in the groin is compared with that in the axilla. The clinical picture presented by this patient suggested Milroy's disease.

On August 3, 1936, a patient came into my office with a swollen arm following a radical operation for the cure of cancer of the breast. The appearance of her arm resembled in a striking manner the leg just mentioned. The fingers, forearm, and arm were swollen to their capacity; the skin appeared as though it would break if subjected to any further pressure. It had the appearance of being distended so rapidly that it had not had sufficient time for the development of fibrosis. The chest on the affected side in this patient offered mute evidence of the amazing mutilation of which a surgeon can be guilty. As contrasted with the normal side, the affected side showed a depressed area the floor of which was composed of epithelized scar tissue firmly adherent to the underlying bony cage formed by the ribs. This type of tissue also covered what was once an axilla. The complaint of the patient, in addition to the swollen arm, was that she felt as though she were in a vise and could scarcely breathe. She had considerable pain in her arm, not sharp but a dull ache. This patient and the one just mentioned had a blockage of a group of lymphatics followed by a swelling of the areas drained. In the first case the lymphatics of the thigh were involved, and in the second the lymphatics and blood in the arm. In the first case there was something, as yet undiscovered, which permitted an easing of the tension and allowed circulation to be re-established. The second patient was not so fortunate; for her there was no release.

According to the literature edema in elephantiasis filariosa is not caused by blockage of the lymph glands and vessels alone. There is something else necessary. It would seem, therefore, that the cause or causes for the 2 clinical pictures

Fig. 1. Swollen arm, brawny arm, or elephantiasis chirurgica.

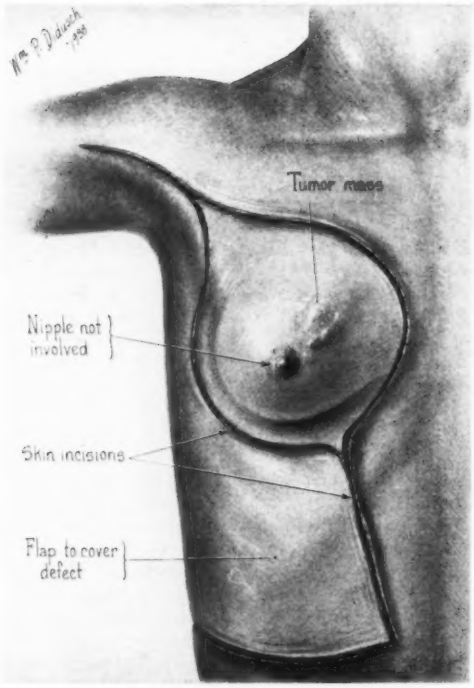

Fig. 2. Outline of incision permitting adequate exposure and thorough dissection of the axilla with reasonable margin of skin to be left, and extension to permit adequate exposure to the opposite side of the sternum, sheath of the rectus muscle, and latissimus dorsi.

Fig. 4. Division of the pectoral muscles.

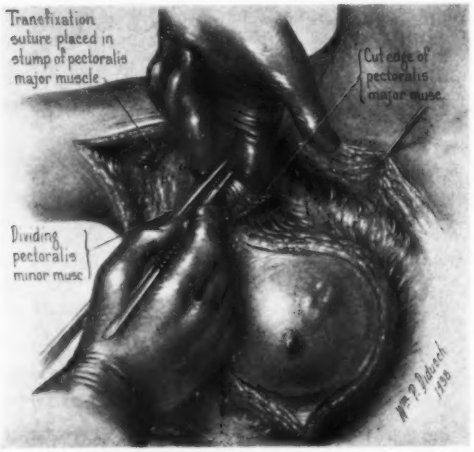
Transfixation suture placed in stump of pectoralis major muscle
Cut edge of pectoralis major muscle
Dividing pectoralis minor muscle

Fig. 5. Transfixion and ligation of the insertion of the pectoralis major and division of the pectoralis minor.

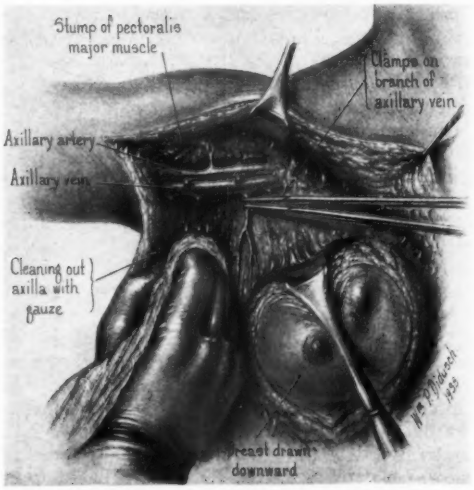

Fig. 6. Stripping of the axillary vessels preliminary to dissection of the axilla.

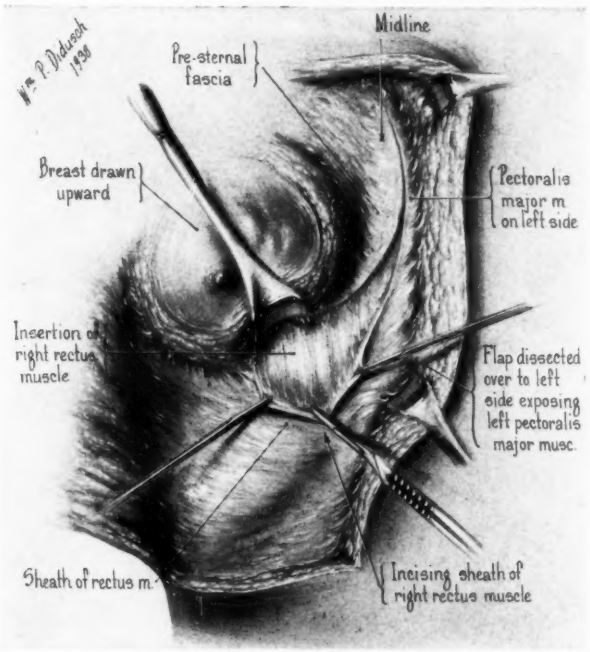
Midline
Pre-sternal fascia
Breast drawn upward
Pectoralis major m. on left side
Insertion of right rectus muscle
Flap dissected over to left side exposing left pectoralis major musc.
Sheath of rectus m.
Incising sheath of right rectus muscle

Fig. 7. Dissection of the fascia on the opposite side of the midline exposing the fibers of the pectoralis major; also for the removal of the upper portion of the sheath of rectus in anticipation of cancer cells driving against the lymph current.

cited is not due to the disturbance within the vessels and glands alone but also to something in the environment about the vessels. In a swollen arm which returns to normal a favorable change takes place in the environment, while in the permanently swollen arm there must be, in addition to the disturbance within the vessels, a change in the environment constantly present, operating continuously and increasingly to bring about a condition so distressing as that shown in Figure 1.

While many contributions have been made concerning swollen arm, brawny arm, or elephantiasis chirurgica following operation for cancer of the breast, no one satisfactory explanation has been offered. In the new and rapidly accumulating literature no one has explained why one patient operated upon for cancer of the breast, using the complete method, should be plagued by a swollen arm; while another patient treated by the same method should escape entirely; or why one patient should have a swollen arm immediately after the operation, clearing up later; while in another the swelling may be deferred for a long time but then become permanent once it is established.

Halstead has mentioned what most of us have observed, that these swollen arms are easy prey to streptococcus infection. He suggested that nerve injury may, in a measure, be responsible for this. That would hardly seem acceptable in the light of MacCallum's experiment in which he demonstrated that the injured limb reacted to infection in a manner very similar to the uninjured limb.

Nothing has been said relative to the fate of the artery in the dissection of the axilla or following it. We have evidence to prove that the same artery is on occasion embarrassed by pressure exerted by a cervical rib resulting in aneurism distal to the constriction. It would seem by analogy that a similar condition would be produced in the axilla, yet I have never seen it.

While swollen arms have frequently resulted from massive cancers in the axilla or neck without operation of any kind, one gains from the litera-

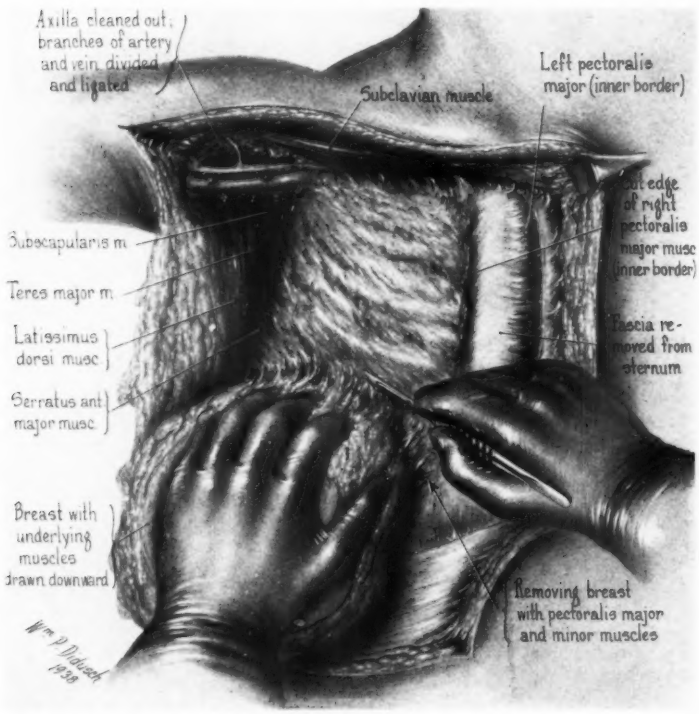
Axilla cleaned out, branches of artery and vein divided and ligated
Subclavian muscle
Left pectoralis major (inner border)
Cut edge of right pectoralis major musc (inner border)
Fascia removed from sternum
Subscapularis m
Teres major m
Latissimus dorsi musc
Serratus ant major musc
Breast with underlying muscles drawn downward
Removing breast with pectoralis major and minor muscles
Wm P Didusch 1928

Fig. 8. The axilla cleaned, exposing the scapularis, teres major, latissimus dorsi, anticus, serratus; the subclavian muscle, and pectoralis major on the opposite side. The scraping off of the pectoral minor muscle leaving tiny fragments of muscle tissue.

ture the impression that this difficulty in its post-operative form did not exist as a menace until knowledge of the pathology of cancer of the breast, first noted by Heidenhain, compelled the complete removal of both pectoral muscles in order to carry out a surgically correct procedure for the cure of cancer of the breast. By these data one wonders whether the changed environment is brought about by the more complete dissection afforded by better exposure following the removal of these muscles, or whether the muscles acted as a framework to permit the relaxed condition of the tissue about the vessels and lymphatics to accommodate the changes in volume of these tissues when called upon to meet unusual emergencies; or whether these structures acted as adjuvants to the two circulatory systems, serving as a medium of exchange in the reconstruction of the lymphatics in those patients whose axillæ were cleaned without destroying the muscles.

The classic experiment of Reichert immediately comes to mind. He demonstrated very conclusively the ability of the lymphatics by practically amputating the leg of a dog and noting the rapid re-establishment of circulation through the scar tissue. That, while convincing for the leg, does not seem applicable to the very markedly different environment offered by the axilla. In the former case there is great mobility of tissue, in the latter there is practically none.

Halstead, in his contribution on the swollen arm published in the Johns Hopkins Hospital *Bulletin*, in 1921, suggested that infection at the time of the operation or following the operation may be responsible, in part at least, for this condition. It was he who gave it the name elephantiasis chirurgica.

The following case would seem to contradict Halstead's view, in a measure at least. Mrs. H. was operated upon by me in 1913 for cancer of the breast. She had an uneventful convalescence

Fig. 9. The dissection of the outer surface of the latissimus dorsi muscle.

and for 25 years had no trouble whatsoever. Two years ago she wrote me stating that she was perfectly well except that her forearm and arm on the affected side were beginning to give her trouble and that her fingers and hand had begun to swell.

Other writers have offered many suggestions but most of them apparently are of the opinion that the swelling is due to destruction of the lymph filtering plant in the axilla with partial or complete destruction of the veins plus tension which constantly tends to increase as the result of the contraction of scar tissue in a more or less rigid environment. If this be true, any treatment to be effectual must be directed toward a re-establishment of the axilla in a manner at least approaching that which obtained previous to surgical interference. Since this condition seems to have followed the removal of the pectoral muscles the new framework in the re-establishment of the axilla must, in a measure, simulate the function of these muscles. Halstead saw that, and in his clinic the accepted dictum was that the person who made the incision should not have to close it, and that it was bad surgery further to increase the tension about the axilla by re-uniting flaps under pressure. It was he who suggested that instead of re-uniting the flaps under pressure the other extreme should be effected by pressing them back thus permitting the greatest amount of freedom of the tissue. The remainder of the deformity was covered by skin grafts. He noticed a marked improvement following this operation.

Utilization of the pectoral minor muscle has been suggested by several surgeons. Probably the first was the late John B. Murphy of Chicago; but he stated that inasmuch as cancer cells had been found in the major muscle and also between the two muscles it would seem rather risky to utilize either of these muscles in a plastic operation.

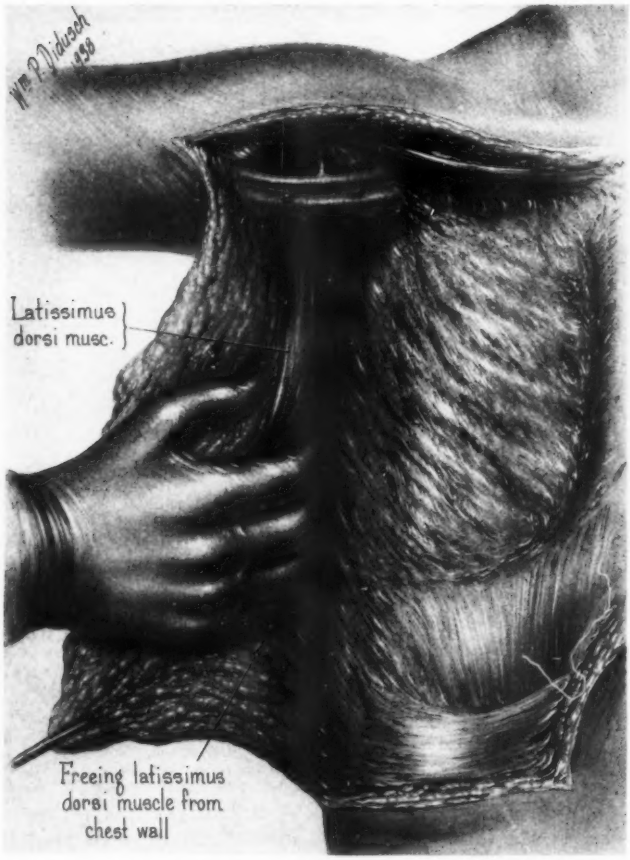

Fig. 10. Dissection of the inner surface of the latissimus dorsi muscle.

In our efforts to prevent morbidity following an operation upon the breast the one thing that transcends all others in importance is the fact that we are dealing with cancer, and no tissue that will be a threat to the patient should be allowed to remain.

Transplantation of fat has been suggested and perhaps would be of benefit, but to be successful it would seem that the structure transplanted must be a viable structure with a superabundant blood supply and the possibility of simulating, in a fashion, the function that the pectoral muscles probably played in preventing contraction before the complete operation came into use.

On September 17, 1936, immediately after visiting the patient mentioned at the beginning of this paper, I operated upon a patient who had cancer of the breast. With the swollen arm and distressing condition of that patient fresh in my mind I attempted a new method which promised to bring about the desired result, as mentioned in conjunction with the function probably played by the pectoral muscles.

The only available muscle, and muscle tissue seemed preferable to any other for this purpose, which would lend itself physiologically and mechanically was the latissimus dorsi. It has the advantage of being away from the lymph current which drains the breast. It has a broad origin, fan-shaped, the greater part of which is made up of muscle tissue, a reputedly desirable medium for the restoration of lymphatic circula-

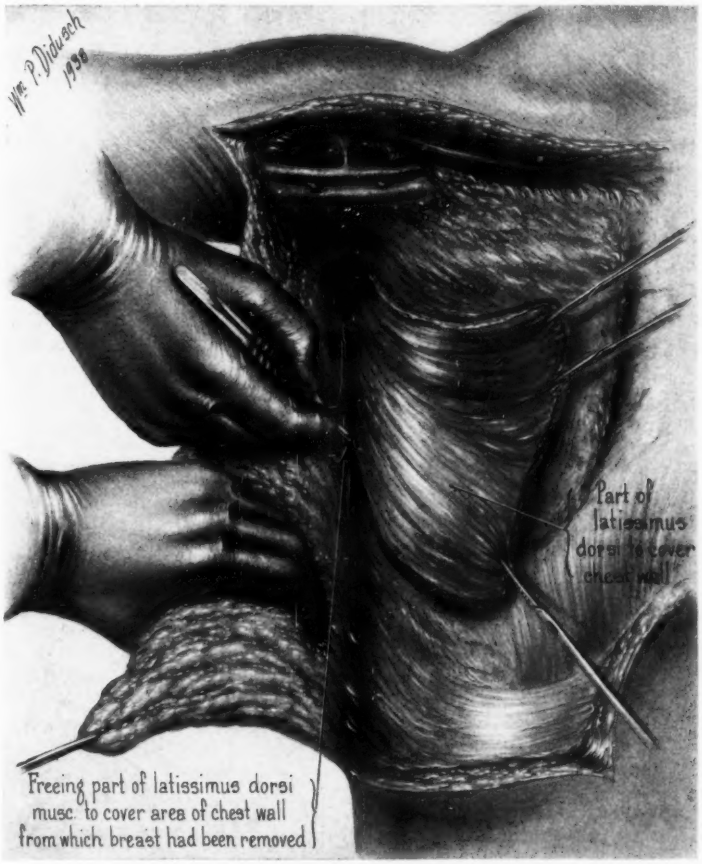
Wm. P. Didusch
1938
Part of latissimus dorsi to cover chest wall
Freeing part of latissimus dorsi musc. to cover area of chest wall from which breast had been removed

Fig. 11. Freeing of the latissimus dorsi preliminary to transplantation.

tion. It will cover a large area of denuded chest wall. It may be dissected with the greatest ease, both from its origin and from the bands of muscle tissue attaching it to adjacent structures. While it narrows as it approaches its insertion, it is of sufficient volume to cover not only the axillary vessels but also the entire denuded area from which the breast was removed. The attachment of this muscle to the clavicular portion of the pectoral major in appropriate cases, to the subclavian muscle, and to the small remnants of the pectoral minor muscle left for that purpose, is effected by silk sutures. The nerve and blood supply are easy to preserve if proper care is exercised during the original axillary dissection. In those cases of deferred skin grafting the area covered by muscle presented a very desirable, smooth surface with abundant blood supply. The small area which could not be entirely covered with muscle presented a greatly inferior, granulating surface.

Since that operation we have had 12 cases suitable for the application of this method. There has been no occasion to regret the procedure in any of these cases. The operation can be done in 1½ to 2 hours. The transplantation accomplishes the following things: (1) It obliterates a troublesome dead space. (2) It covers the vessels with tissue of a pliability resembling in a measure the looseness which originally existed in the axilla. (3) It increases the mobility of the shoulder joint. (4) By attaching it to the subclavian

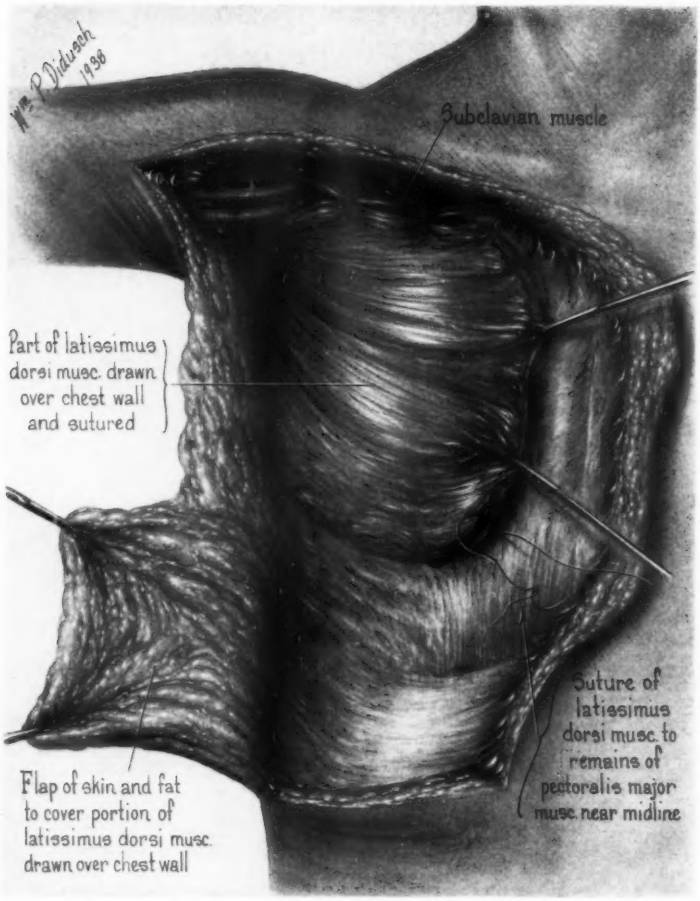
Wm. P. Didusch 1938
Subclavian muscle
Part of latissimus dorsi musc. drawn over chest wall and sutured
Suture of latissimus dorsi musc. to remains of pectoralis major musc. near midline
Flap of skin and fat to cover portion of latissimus dorsi musc. drawn over chest wall

Fig. 12. The latissimus dorsi being sutured in its new position.

muscle and the tags of the pectoral minor muscles left for that purpose, it would seem ideally adapted to the regeneration of new blood vessels and lymph vessels. (5) The muscle juice undoubtedly has a hemostatic influence in the small amount of oozing that practically always follows such a radical dissection. (6) It gives a healthy base for skin grafts, either immediately applied or deferred. (7) It lends smoothness and mobility to the tissues about the ribs that were so cruelly left with immediate skin graft resulting in what every surgeon would avoid, namely, scar tissue attached to bone. (8) Finally, it lays the foundation for what we have in mind, namely, to fashion out of the abdominal fat something simulating the original breast.

Elephantiasis chirurgica is a morbid condition having its origin in the completeness with which efforts to cure cancer, following the discovery of cancer cells in and among the pectoral muscles, were made by Willy Meyer and W. S. Halstead. It apparently results from a change in tension of tissues in the axilla, perpetual by nature and of increasing degree; it may become so extensive that amputation of the shoulder joint is advisable; it may follow any and all breast operations.

This operation is an effort to bring about 2 things:

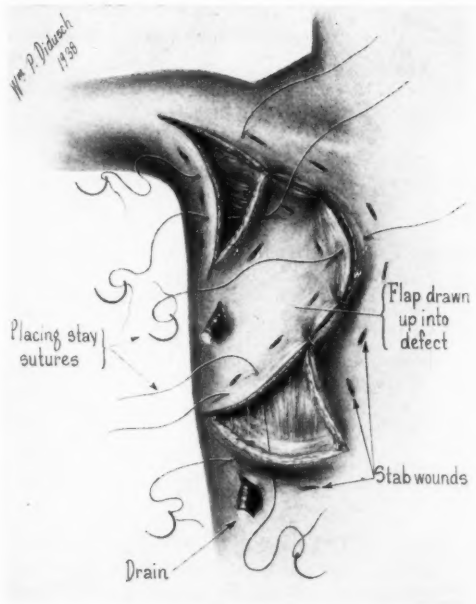

Fig. 13

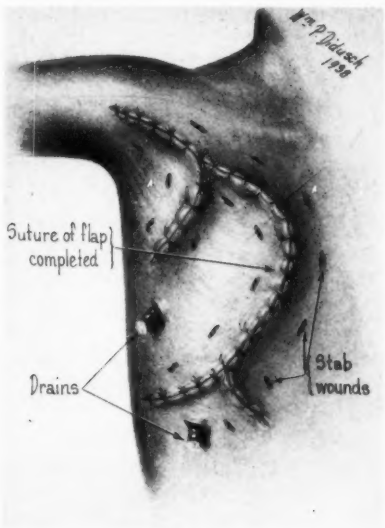

Fig. 14

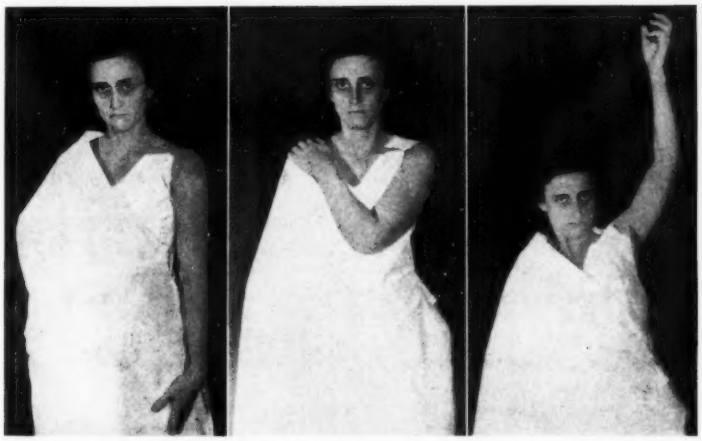

Fig. 15

Fig. 13. An effort to close the incision with a flap from the abdominal wall with perforations on the margins to permit escape of fluid for the purpose of anchoring the flaps by granulation.

Fig. 14. Closure of the incision which has been modified in recent cases.

Fig. 15. The mobility of the arm 10 days after operation.

1. An approach at the time of the operation toward the re-establishment of the axilla by the plastic method to a degree or point as near the original as possible.

2. An effort to construct an artificial breast out of the abdominal fat at the time of operation and thus help to avoid the psychosis following operation.

In order to reconstruct the axilla more completely it may be advisable not only to detach the latissimus dorsi at its origin but also at its insertion and to re-insert it in the coracoid proc-

ess. This would provide a framework for the axilla resembling in many respects the part played by the pectoral minor muscle.

While the mortality of cancer of the breast is constantly improving, the morbidity of the breast is a constant menace and should have the most serious attention of every surgeon operating for that condition.

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EXTRAPLEURAL PNEUMOTHORAX

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COLLAPSE therapy has proved to be the most successful method of treatment of pulmonary tuberculosis. The mechanism of this benefit is not universally agreed upon, but results are attributed to closure of the cavity, rest of the part, circulatory changes, and alteration of condition in the tissues resulting in circumstances less favorable for development of the tubercle bacillus. Collapse therapy measures have been successful in direct proportion to their mechanical effectiveness, provided of course there are no serious sequelæ to the operation.

Intrapleural pneumothorax is the most valuable collapse measure but is ineffective, unfortunately, in many cases because of adhesions. Thoracoplasty has been by far the most successful surgical measure but has certain objections in multiplicity of hazardous operations, resulting deformity, and disability. Other members of the collapse armamentarium which have been of some value are: (1) intrapleural pneumonolysis; (2) phrenic nerve operation; (3) extrapleural pneumonolysis (principally paraffin packing); (4) scalanotomy; (5) intercostal neurectomy; (6) various revision and supplementary thoracoplasty; (7) pneumoperitoneum; and (8) oleothorax. Recently a new collapse therapy procedure has been introduced which gives promise of being of definite value. This is extrapleural pneumothorax.

While Tuffier performed this operation in 1910, the real credit of its development and popularity belongs to Graf of Dresden, and Schmidt of Heidelberg. Others who have commented on the subject or reported their experiences are Belsey, Overholt and Tubbs, Rhodes, Monod, Brock, Roberts, Sellors, and Sauer.

From the Municipal Tuberculosis Sanitarium of Chicago.

INDICATIONS

The exact indications and possibilities of the operation cannot as yet be definitely determined. Brock states that "extrapleural pneumothorax should be done in every case in which intrapleural pneumothorax is indicated but fails," although he is of the opinion that in certain cases thoracoplasty is fundamentally the operation of choice.

We have proceeded upon the theory that the earlier lesions and smaller soft cavities would be easiest to collapse, and cases with large, thick walled cavities and heavy apical caps would be controlled best by thoracoplasty. Needless to say, the operations are reserved for those cases in which pneumothorax is not possible and in which the other more simple measures will probably not be effective. One outstanding adaptation of the procedure will probably be found in controlling progressive contralateral lesions in pneumothorax and thoracoplasty cases. We believe that any hope that extrapleural pneumothorax will largely replace thoracoplasty will not be realized.

OPERATION

We have chosen an approach similar to that for an upper stage thoracoplasty believing that we should be prepared to resort to thoracoplasty if conditions suggest that this would be the wiser.

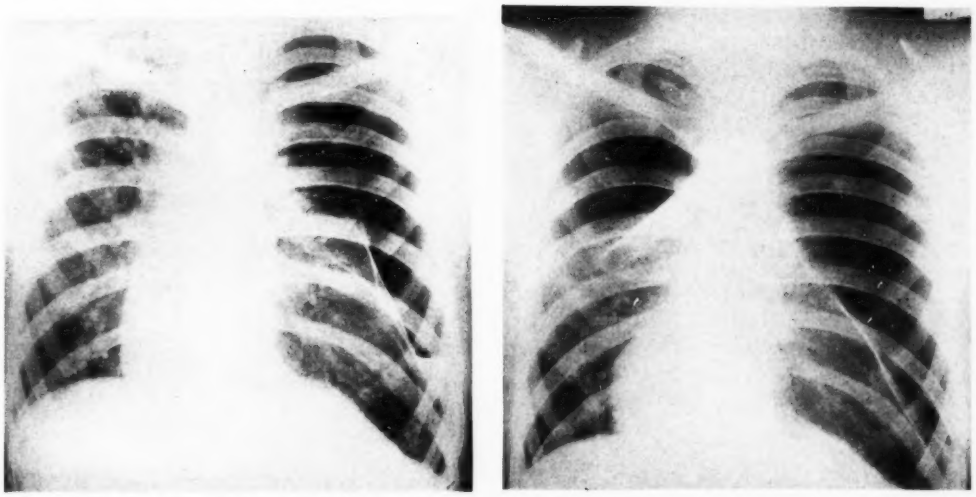


Fig. 1. Case No 36799. F. J., white male, age 21 years. Admitted to Municipal Tuberculosis Sanitarium October 11, 1935. Diagnosis: far advanced pulmonary tuberculosis; sputum positive on admission. Artificial pneumothorax, right, started November 1. 1935; continued at present time. Sputum positive. Phrenic resection, left, November 19, 1936; Sputum positive. Extrapleural pneumothorax, left, established March 28, 1938. Sputum negative since; patient in excellent general condition. Roentgenograms made February 8, 1938 and April 20, 1938.

Anesthesia has been local infiltration with novocain supplemented with cyclopropane gas. A paravertebral incision is made transgressing the trapezius and rhomboid muscles and a few fibers of the latissimus dorsi. About 4 to 6 inches of the fourth rib is removed, and then a cleavage plane

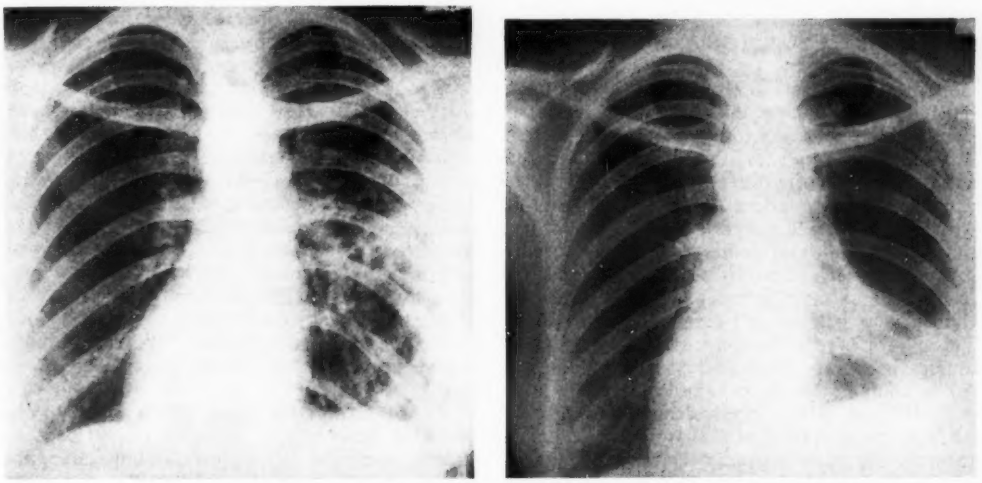
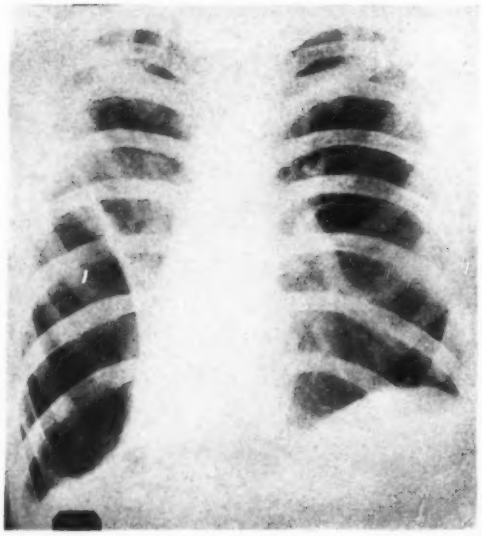


Fig. 2. Case No. 44572. R. J., white female, age 26 years. Admitted to Municipal Tuberculosis Sanitarium October 13, 1937. Diagnosis: far advanced right apical tuberculosis; sputum positive on admission. Artificial pneumothorax, right, instituted and discontinued in 5 months because of apical adhesions. Extrapleural pneumothorax established April 28, 1938. Sputum positive through May, 1938. Phrenic paralysis done June 13, 1938. Sputum negative since; condition excellent. Roentgenograms taken April 20, 1938 and November 16, 1938.



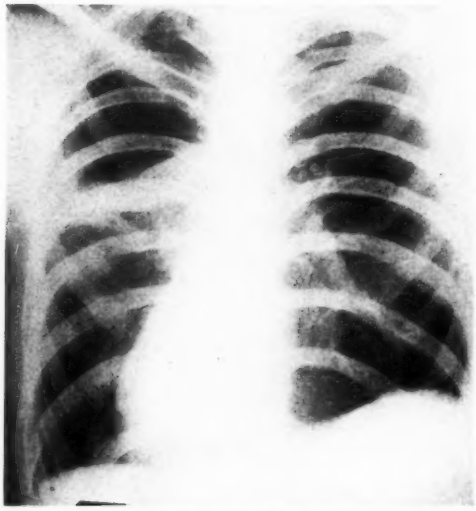


Fig. 3. Case No. 45169. T. K., white male, age 26 years. Admitted to Municipal Tuberculosis Sanitarium January 25, 1938. Diagnosis: far advanced pulmonary tuberculosis; sputum positive on admission. Extrapleural pneumothorax established June 30, 1938. Sputum negative since; patient in excellent condition; discharged December 2, 1938. Roentgenograms taken April 26, 1938, and July 27, 1938.

between the external surface of the parietal pleura and the endothoracic fascia is established. Stripping in this plane is continued over the apex much in the manner of the Semb apicolysis and then continued downward toward the diaphragm as far as seems indicated in the individual case. Complete hemostasis is most important. We have relied largely on hot, moist packing, but occasionally ligation or coagulation were necessary.

Next the wound is tightly closed with a suture approximating the adjacent ribs. We have partially filled the artificially established cavity with saline, believing it will inhibit the formation of blood clots and facilitate future aspirations.

A combination of intrapleural and extrapleural pneumothorax may be feasible. Sellors suggests that this can be done in 4 different ways: (1) the 2 spaces can be maintained separately; (2) a communication can be made at the time of operation; (3) a communication can be established later with the aid of the thoracoscope; and (4) the extrapleural stripping of the apex can be made through the pneumothorax space, much as in intrapleural pneumonolysis.

Sauer reports 12 cases of bilateral extrapleural pneumothorax. We have used the operation in combination with contralateral collapse by pneumothorax and by thoracoplasty.

POSTOPERATIVE CARE

The immediate postoperative course has been mild in all of our cases, except one, and recovery uneventful. In the one case there seemed to be a state of shock from some unexplainable cause from which the patient recovered rapidly after the second day. The inevitable accumulation of bloody fluid is removed in 24 hours and replaced with air. This maneuver is repeated as indicated at periodic intervals. We believe it of extreme importance to keep the space free of fluid. The space seems easily maintained, there is little tendency for the air to escape, and there has been very little subcutaneous emphysema in our cases. We have given refills at weekly intervals, the amount of air absorbed being 100 to 400 cubic centimeters in that interval. We have maintained positive pressures, as high as 20 to 40 centimeters of water, to retard the gradual process of obliteration of the space which we have observed in some cases. Collapse should be continued, if possible, as long as in a comparable case of intrapleural pneumothorax.

COMPLICATIONS

Complications, such as hemorrhage, infection, and perforation of the lung, have been encoun-

tered or suggested. Overholt and Tubbs report 4 infected spaces in 31 operations, 3 with bronchial fistulas.

Roberts reports 3 deaths, 1 from hemorrhage in 33 cases. Brock reports 5 deaths in 50 cases.

The only immediate difficulty we have experienced was the 1 postoperative reaction already mentioned and best described as shock. One patient developed a simple tuberculous empyema, but this apparently has been controlled completely with the aid of oleothorax. Another patient developed an alarming pulmonary hemorrhage following aspiration but recovered with no ill effects. Two of our patients have developed a low grade non-specific infection in the extrapleural space. One has been controlled completely by repeated aspirations and irrigation and the other seems virtually controlled. In the only case in which we have combined intrapleural and extrapleural pneumothorax the space became infected 2 months after the operation and is still being aspirated. We have had no deaths and no instances of spread of the tuberculous disease to the other lung or other parts of the body. Progressive obliteration of the space will probably follow slowly in most cases, but as yet this has not threatened the effectiveness of the collapse in our otherwise successful cases.

RESULTS

The end-results in tuberculous cases cannot be determined for many years. However, the immediate results have been very encouraging and on the basis of experiences with other collapse measures, we would predict that most of the favorable effects will be permanent.

Of the 22 patients operated upon 14 have what appears to be an adequate collapse with closure of cavities and negative sputum. Five others have a good collapse but remain positive. In 3 patients the collapse appears inadequate and will be or has been discontinued.

CONCLUSIONS

1. Extrapleural pneumothorax will undoubtedly prove to be a valuable collapse measure.
2. A posterior approach with resection of the fourth rib seems to be most practical.
3. Careful technique and a faithful postoperative management are most important for success.
4. The exact possibilities and limitations of the operation are still to be determined.

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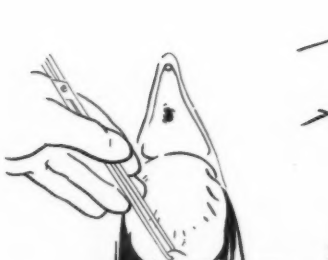

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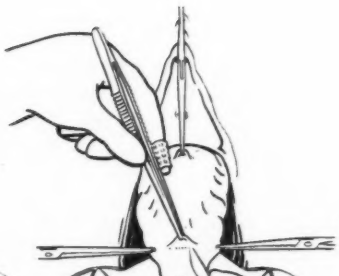

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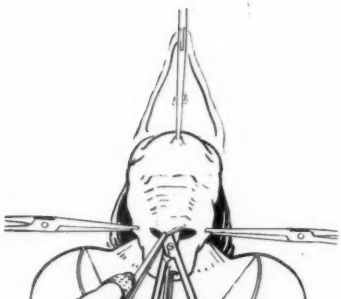

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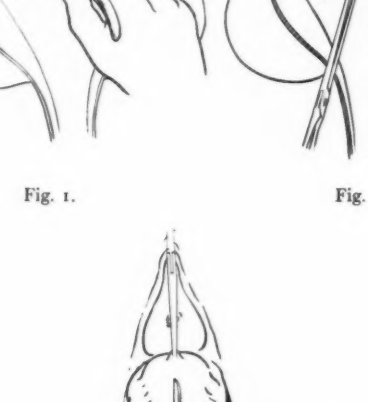

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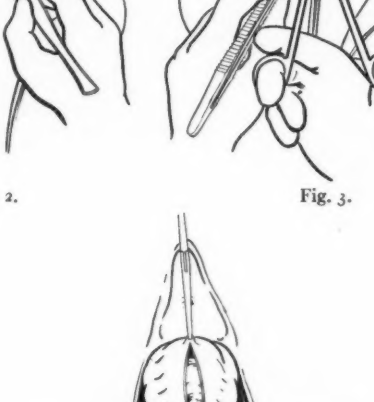

Fig. 5a.

Fig. 1. Dilating the cervix. The cervix is dilated to a No. 12 Hegar. This step helps in the insertion of the sutures in the cervical canal during the fashioning of the new cervix. A curettage is done if malignancy is suspected. A vaginal hysterectomy can be done if cancer is found. Vaginal hysterectomy is one method of treating prolapse.

Fig. 2. Applying the "three forceps." A pair of Kocher forceps is applied laterally, and these are known as Fothergill's points. Their exact position varies with the degree of prolapse, size of the cervix, etc. They should be at the level or slightly below the level of the internal os. The points of the forceps should just meet when they are approximated in front of the cervix. A third forceps is applied in the midline, usually about 1 inch down from the urinary meatus. The area between Fothergill's points is now picked up with a dissecting forceps, and incised.

Fig. 3. Dissecting the anterior vaginal wall from the bladder. A pair of curved scissors is now gently inserted through the incised wound, and pushed upward, dissecting as shown the bladder off the anterior vaginal wall.

Fig. 4. Incising anterior vaginal wall. A pair of Kocher forceps applied to the cut edge makes excellent traction, and the vaginal wall is incised to the "third" forceps with care not to wound bladder and lower part of urethra.

Fig. 5a. Lengthening transverse incision. Incision started in Figure 2 is carried laterally to Fothergill's points.

The Treatment of Uterine Prolapse.—H. W. Johnston.

THE TREATMENT OF UTERINE PROLAPSE

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UTERINE prolapse is a purely vaginal occurrence. Before proceeding to any particular operation designed for its relief, it is wise that we consider carefully a few anatomical facts. The supporting mechanism of the genital tube and its contents is made up of two diaphragms. The upper diaphragm consists of the two cardinal ligaments. These comprise the parametra, the two utero-sacral ligaments or folds, the condensation of connective tissue at the bladder neck, at the vaginal vault, and at the lateral sides of the vagina. These masses of connective tissue resemble a fan. They extend outward and are attached to the side walls of the pelvis. The lower parts of the cardinal ligaments can be especially well seen during the dissection in the radical operation for malignant disease of the cervix. Their importance in maintaining the uterus in its normal anatomical position is incontestable. Prolapse of the uterus and vaginal vault is impossible with healthy, intact, and well supported cardinal ligaments.

The bladder rests upon, and is supported by, a musculofascial sheet, the uteropubic fascia. The term describes its attachments. When this sheet is torn or stretched, a cystocele results. A similar sheet extends along the posterior vaginal wall. It supports the rectum. A rectocele follows when it is damaged.

The lower diaphragm is called the pelvic floor. The structures forming the pelvic floor from within outward are:

1. The pelvic diaphragm:
   a. Peritoneum.
   b. Levator ani muscles with their fascias above and below.
2. The urogenital triangle:
   a. The two layers of the triangular ligament with the sphincter urethræ muscle.
   b. The crura of the clitoris and the bulb (sphincter vaginæ).
   c. The superficial muscles of the perineum.
   d. Colles' fascia, fat, skin (see Figure 5b.).

The levator ani and coccygeal muscles form one sheet. This sheet is thrice perforated in the midline by the urethra, vagina, and rectum. These tubes are surrounded by muscle fibers and connective tissue from this muscle sheet. Injury from childbirth to this complicated supporting mechanism or atony of the pelvic diaphragm muscles with their associated fascias above and below leads to prolapse.

Uterine prolapse is complete or incomplete with all sorts of degrees and variations in between. In a number of prolapse cases, a cystocele is present; in others, the bladder descent is negligible. Most have a deficient perineum, a few have not. In others, a small cul-de-sac, hernia of Douglas's pouch is present and one should be ever on the alert, for such a hernia. Failure to recognize this condition when operating for uterine prolapse will cause the patient a great deal of disappointment when she finds that another operation is necessary to correct it.

There is no branch of surgery in which the ingenuity of the surgeon is so taxed as in the field of constructive gynecology. Anyone who adopts one line of procedure to the complete exclusion of all others—well he hasn't stopped to think.

For the aged, with minor degrees of uterine descent and a cystocele, the interposition opera-

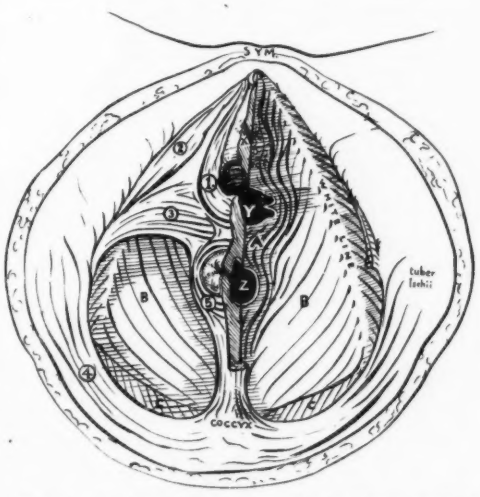
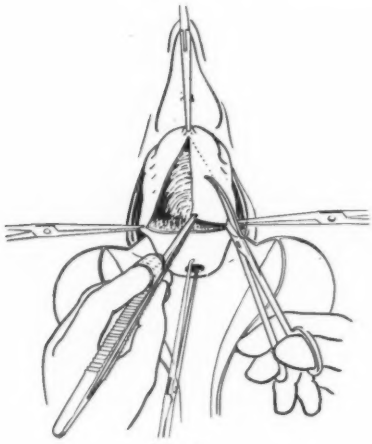


Fig. 5b. A bisected pelvic floor showing the superficial and deep structures. *X*, Urethra; *Y*, vagina; *Z*, rectum.

A, Pubococcygeus; *B*, iliococcygeus; *C*, ischiococcygeus (coccygeus in man), comprising the levator ani muscle; *D*, sphincter urethræ muscle.

1, The bulb or sphincter vaginæ; *2*, the crura of the clitoris; *3*, the superficial perineal muscle; *4*, the gluteus maximus muscle; *5*, the sphincter ani muscle.



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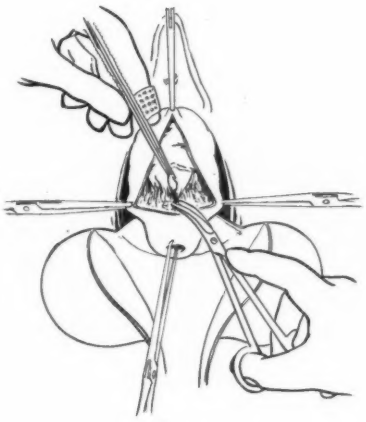

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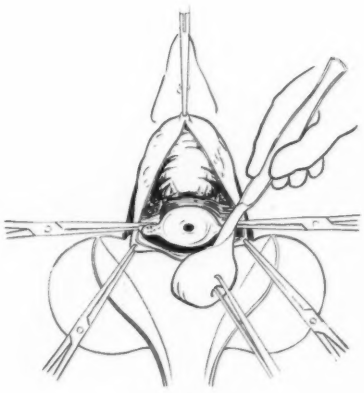


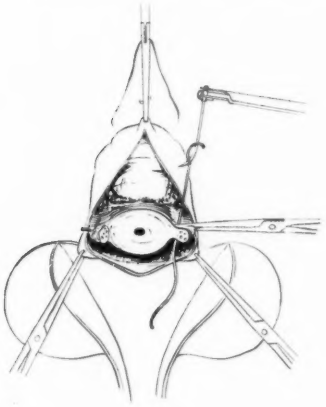
Fig. 9.

Fig. 6. Excising part of the anterior vaginal wall. The triangular area of mucous membrane situated between the three forceps is now dissected free from the bladder wall and removed.

Fig. 7. Dissecting the bladder from the cervix. This is best done with scissors supplemented by pressure from the gauze covered finger after the first attachment of the cervix to the bladder has been cut away. The lower limits of the bladder can be easily felt with the gloved fingers—the bladder then picked up with a dissecting forceps, and the first part of the dissection started with scissors. It is of the utmost importance that the bladder be freed well from the sides and front of the cervix and pushed well up until the uterovesical pouch is reached. Failure to observe this warning may result in ureteral and bladder damage during the introduction of the sutures (see Fig. 14). If hemorrhage ensues, the bleeding points should be carefully clamped and tied with No. 1 plain gut.

Fig. 8. Incising the posterior vaginal wall. A transverse incision is now made between Fothergill's points behind the cervix. The incision is deepened to the cervix posteriorly, and a flap of vaginal wall is raised up.

Fig. 9. Clamping the parametra, dividing, it and amputating the cervix. The bladder should be pushed well up before the two Kocher forceps are applied. They include in their "bite" the lateral cervical vessels. The tips of the forceps should "nip" the side of the cervix. Failure to attend to this may result in a lot of troublesome bleeding after the cervix has been amputated. The cervix is amputated by simple transverse incision.



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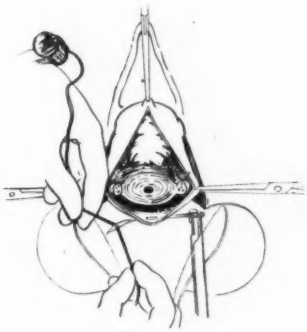

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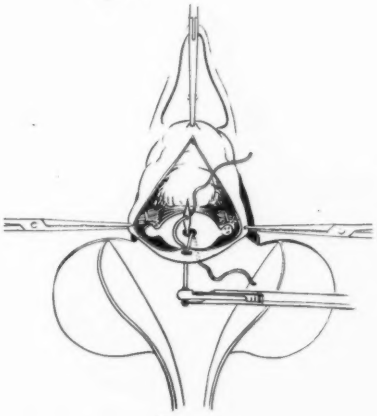


Fig. 12.

Fig. 10. Tying the vessels. Reverdin's needle should be made to grasp a small piece of the cervix so anchoring the ligature.

Fig. 11. The posterior infolding suture. The posterior flap is pulled down and Reverdin's needle is passed as shown, so that when withdrawn fully threaded the infolding suture is formed. It gives a much superior and firmer apex to the flap than if the needle were only made to penetrate the flap the once.

Fig. 12. Fashioning the cervix posteriorly. The posterior infolding suture has now been tied once at the apex of the flap to make the suture immovable during the turning in of the flap. Reverdin's needle is passed; made to penetrate the posterior vaginal wall, the posterior part of the cervix, and emerge in the cervical canal. It is now threaded with one of the free ends of the suture attached to the apex of the flap and withdrawn. The procedure is repeated—the remaining part of the suture grasped in the eye of the needle and again withdrawn.

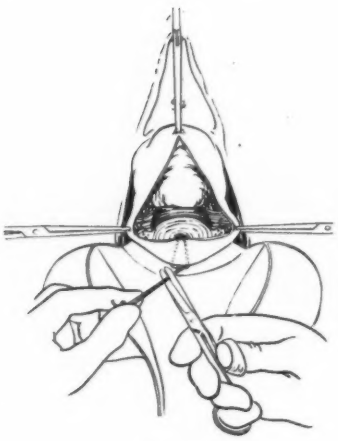
Fig. 13a. Tying and cutting the posterior "infolding" suture. On tying the two ends of the suture the posterior flap of mucous membrane is now brought firmly against the cut edge of the cervix. The apex of the flap is firmly anchored in the cervical canal.

Fig. 13b. Inserting the "encircling sutures." One of the dangers in any operation involving the cervix is oozing—troublesome oozing. If it persists after the posterior infolding suture has been tied, I often insert two "encircling sutures." Reverdin's needle is passed from the cervical canal directed outward and lateralward, traversing the cervix, and made to penetrate the posterior vaginal wall, lateral to the posterior infolding suture. It is then threaded, withdrawn, and tied. The same procedure is repeated on the corresponding side. The insertion of these sutures is not carried out as a routine. Careful attention to the securing and ligaturing of the cervical vessels makes it rarely necessary (see Figs. 9 and 10). However careful, some cervices are very vascular, and a number of vaginal flaps ooze excessively. It is in such a case the encircling suture is employed to good effect.

Fig. 14. Inserting a modified Fothergill's suture. This suture starting at Fothergill's point on one side, passes through the vaginal mucous membrane—the parametra—an area of the lower uterine segment just above the internal os—the parametra of the opposite side, and the mucous

tion is useful. Vaginal hysterectomy by the method of Mayo is very good if the uterus needs removing at the same time. For the old and feeble and in those in whom the question of further coitus can be forever answered in the negative, LeFort's operation is recommended. The Fothergill operation is a very useful one. If a cystocele is present, it can be repaired at the same time. Frequently, there is a cystocele. All operations for vaginal or uterine prolapse are incomplete without a perineorrhaphy. A perineorrhaphy should always be done.

A series of descriptive drawings showing an operation for uterine prolapse is presented. The principles are those of Fothergill. The technique—that of fashioning the cervix and introducing Fothergill's suture—is different. I would like to take this opportunity of acknowledging my indebtedness to this brilliant British gynecological surgeon.



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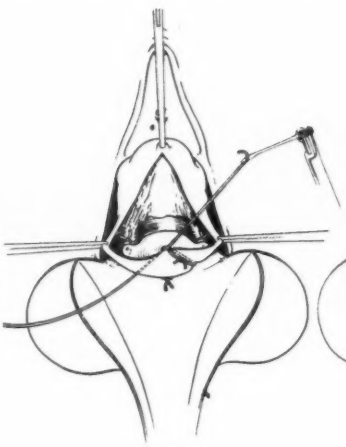
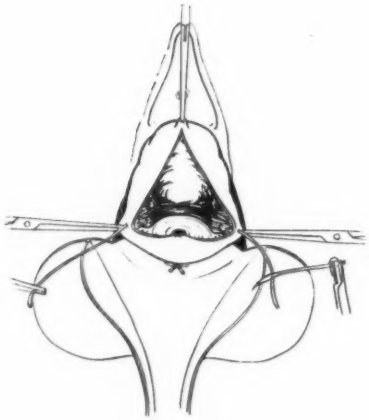


Fig. 13b.

Fig. 15.



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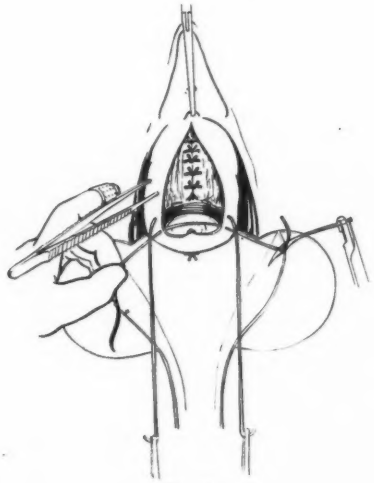


Fig. 16.

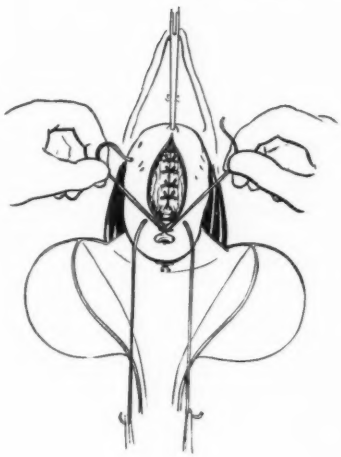
membrane emerging at Fothergill's point of the opposite side.

Fig. 15. Repairing the cystocele. Interrupted sutures draw together the torn or stretched pubocervical layer of pelvic fascia. In the regular repair of the cystocele the final suture passes through the supravaginal cervix so that when tied the bladder is entirely shut off from below. This suture is purposely omitted in this operation. It would draw the cervix too far forward when tied. When Fothergill's suture is tied later on, the small opening between the supravaginal cervix and the last pubocervical suture will be covered and "plugged" with parametra and paracervical tissue.

Fig. 16. Inserting the anterior flap suture. Reverdin's needle is now passed through the mucous membrane of the anterior vaginal wall in two places at distances of approximately 1 inch from the apex of the newly formed posterior flap (see Figure 12). These points, of necessity, will vary with the size of the cervical stump to be covered, i.e. a large stump requiring more mucous membrane, and consequently the "suture points" would be further out. With a little ingenuity on the part of the operator the flap can easily be formed.

Fig. 17. Approximating the two anterior flaps and tying a knot. The anterior vaginal wall flaps have been brought together and the suture tied with one knot so as to make it immovable during the next step of turning in the flap.

Fig. 18. Fashioning the cervix anteriorly. Reverdin's needle is now passed through the anterior part of the cervix into the canal, one of the sutures inserted in the eye of the needle and withdrawn. The needle is re-inserted, the



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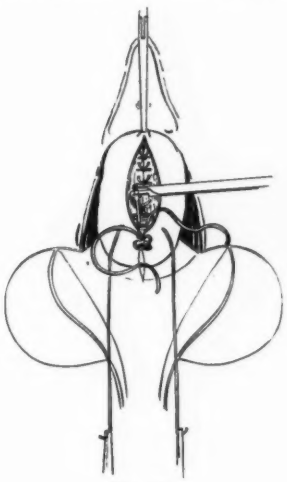

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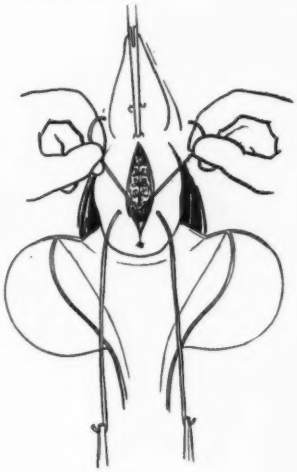

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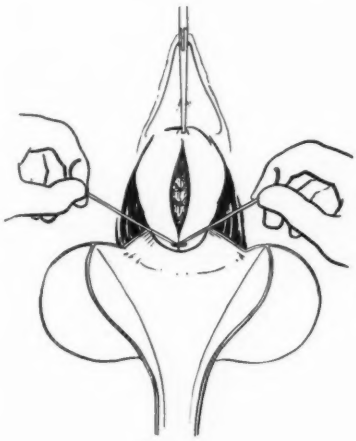

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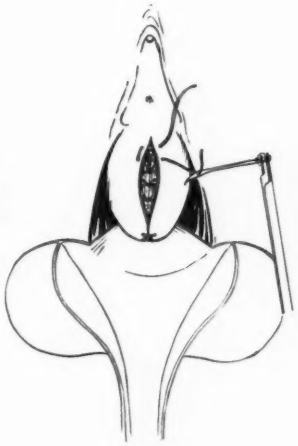

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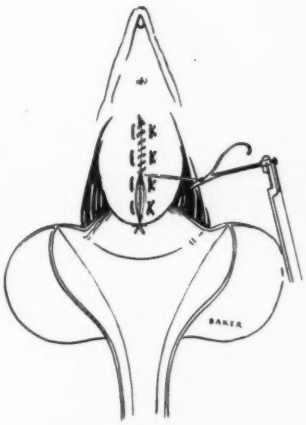


Fig. 22.

other suture grasped in the eye, and the needle withdrawn. A tenaculum applied to the anterior lip of the amputated cervix steadies it during this procedure, and keeps the modified Fothergill's suture well forward.

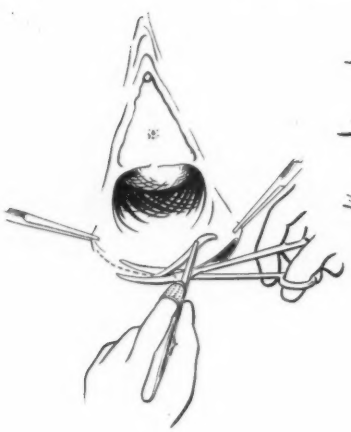
Fig. 19. Tying the anterior infolding suture. When the ends are drawn taut and tied, the anterior flaps roll in—cover up the anterior part of the cervix—and complete the fashioning of the cervical canal.

Fig. 20. Tying the modified Fothergill's suture. In this way Fothergill's points are united in front of the cervix, and as mentioned before in Figure 15, the parametra being approximated in front of the cervix, the hernial orifice, between the last suture in the pubocervical fascia and the supravaginal cervix, is closed. The bladder also is firmly supported. Particular reference was made in the introduction of the modified Fothergill's suture that the suture be inserted into the uterus above the region of the internal os, or what I choose to call the "pivotal point," so that now when tied tightly the cervix is forced backward, and the body of the uterus is drawn forward, thus correcting any tendency to retroversion of the uterus.

Fig. 21. Inserting a series of mattress sutures. These sutures are hemostatic; roll the edges out nicely, and when inserted far back take in their "bite" a few fibers of the uteropubic musculofascial sheet so forming an additional barrier against any further bladder descent.

Fig. 22. Suturing the cut edge of the vaginal wall. This is quickly done with a continuous suture.

Fig. 23. A perineorrhaphy should be performed also. The author uses a knife entirely for this dissection. The field of operation is exposed by grasping with two Kocher forceps that part of the introitus close to the lowest carun-



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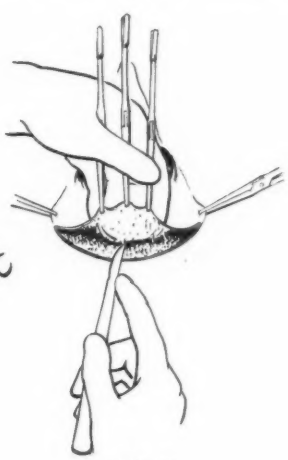

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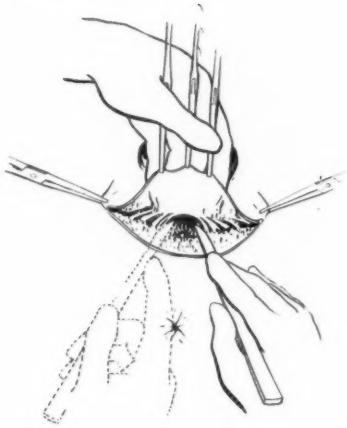

Fig. 25.

Fig. 26.

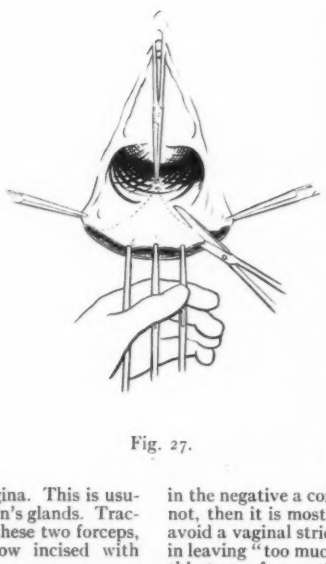

Fig. 27.

culæ myrtiformes on each side of the vagina. This is usually exactly below the opening of Bartholin's glands. Traction is made in an outward direction on these two forceps, and the mucocutaneous junction is now incised with scissors.

Fig. 24. Beginning the separation of the posterior vaginal wall. Three Kocher forceps are now applied to the upper part of the newly made incision, held with the left hand, and the knife is used to dissect up the flap. This can be done rapidly and safely as the pulp of the fingers of the left hand pressed firmly against the flap guides the knife in its course and makes the dissection safe.

Fig. 25. Incising the scar tissue and the superficial structures of the perineum. With the flap raised and protected as before by the fingers of the left hand, the dissection is carried deeper in and further out to the sides. Colles' fascia, fibers of the superficial transversus perinei muscle and the scar tissue brought about by previous tears and lacerations from childbirth are severed until deep in the central part of the perineum the rectal wall can be seen. The knife changed from one side to the other works admirably.

Fig. 26. Separating further the posterior vaginal wall by the gauze covered finger and isolating the levator ani muscle straps. The cellular area between the rectum and vagina separates easily—finger dissection being bloodless. The pubococcygeal straps of the levator ani muscles now are identified. They are not at all superficial as many surgeons think, but lie deep and far out in the perineum. The absolute isolation of this musculofascial structure is essential if a good result is anticipated.

Fig. 27. Removing the redundant vaginal mucosa. The amount of mucous membrane to be removed varies in every individual case. If the question of further coitus can be answered in the negative a considerable amount may be cut away. If not, then it is most important that great care be taken to avoid a vaginal stricture. It is much wiser and safer to err in leaving "too much" rather than "too little." Usually in this type of operation for vault and uterine prolapse, the apex of the flap has to be carried quite high in the vault of the vagina. When this point has been decided upon, a Kocher forceps is applied to denote the upper margin of the flap, and the redundant mucosa is then cut away with scissors.

Fig. 28. Uniting the cut edges of the posterior vaginal wall. The dissection having been finished Reverdin's needle is now passed at the apex, threaded, withdrawn, and the suture tied. Sometimes it is wise to insert the needle again, pass the short end of the tied suture through its eye, withdraw and re-tie. This double knot makes for safety. The short end is then held up with a Kocher forceps and the suturing continued part way down the vaginal walls. The

Fig. 28.

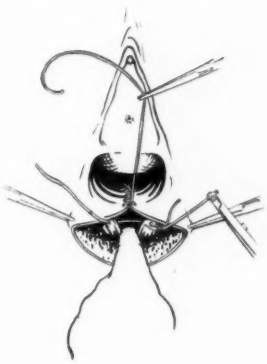

Fig. 29.

Fig. 30.

Fig. 31.

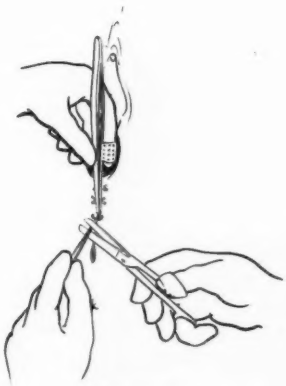

Fig. 32.

Fig. 33.

Kocher forceps holding the short end is then cut away and now transferred to the long end of the suture and held taut.

Fig. 29. Approximating the levator ani muscles. With the pulp of the index finger of the left hand pressing the rectum well back, a series of sutures are inserted, joining together the two levator straps. It is well after tying the first suture to make a vaginal examination. The vagina should admit two fingers easily. If on examination the canal is unduly narrowed, the suture should be removed, and a suitable one inserted. It is well, if at all possible, for the top suture to include with it some of the loose tissue on the posterior vaginal flap. This obliterates the dead space, and tends to control hemorrhage. Three or 4 sutures usually suffice to establish a firm pelvic floor. The sutures should be firmly tied; the top-most with 3 knots.

Fig. 30. Completing the approximation of the cut edges of the vaginal wall. The continuous suture held by the Kocher forceps (Fig. 28) is now further used to bring together the cut edges of the posterior vaginal wall, so fashioning the newly formed vaginal tube. When the skin margin is reached the suture is tied.

Fig. 31. Suturing the superficial structures of the perineum. A few interrupted sutures bring together the fibers of the superficial transversus perinei, Colles' fascia, and superficial fascia. The sutures should be firmly tied with two knots, and the ends cut short to avoid "catgut knot" serum in the perineal wound.

Fig. 32. Closing the wound. Interrupted catgut sutures are used. Particular care should be exercised during this final maneuver to see that the skin edges are well everted. The surgeon with a dissecting forceps everts the edges well while the assistant ties the knot.

Fig. 33. The final suture.[1]

[1]The writer wishes to convey his appreciation to the ever inventive genius, Mr. Victor Bonney. The wrist reels containing the catgut are his, also the modification of Reverdin's needle. The small scissors are my modification of the Kocher scissors, and the dissecting forceps is my own. The forceps is quite useful when used with Reverdin's needle, and where the problem of fat is ever to the fore. The thimble prevents slipping, exerts a steadying influence on the forceps when the surgeon is working in difficult corners, and moreover does not impair the usefulness of the left hand, as can be seen in the sketches of the operation (Fig. 16). The modified Kocher scissors carried by the assistant on the fifth finger of his right hand are also useful. They are always "to hand" when the cutting of sutures or ligatures is desired, and do not impair his usefulness, nor does a good assistant find them cumbersome; quite the reverse, very handy. The material used throughout is chromic No. 2 gut, except for small vessel ligaturing, when No. 1 plain is employed.

AN IMPROVED INCISION FOR THE RADICAL OPERATION FOR CARCINOMA OF THE BREAST

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THE ideal incision for cancer of the breast should provide for the removal of a wide area of skin over the tumor, including the nipple and the areola, while at the same time it should allow for closure of the wound without undue tension on the skin flaps. This should be possible in all early cases without the danger of sloughing from tension, while in more advanced cases so large an area of skin must be sacrificed that skin-grafting will be necessary no matter what type of incision is used. The incision herein described, which I have used for several years, allows of more adequate removal of skin with better closure, thereby reducing to the minimum sloughing and the necessity for skin grafting.

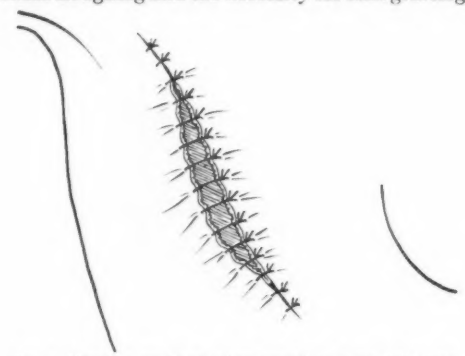


Fig. 1. Tension on flaps when sewed in a straight line.

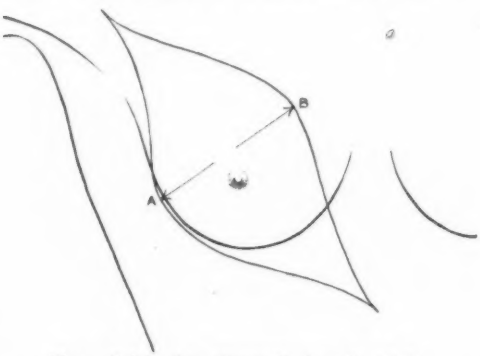


Fig. 2. Points of maximum tension, *A* and *B*.

The skin over the pectoralis major muscle is quite tense and unyielding and does not lend itself well to plastic closure. However, the skin below the pectoralis major and over the axilla is more pliable and quite freely movable in a horizontal or anteroposterior direction, but not so freely movable in the vertical direction. In closing the elliptical incision, the one most commonly used, it is often found that there is undue tension in the center of the incision, or the flaps entirely fail to come together; while at the same time, the lower flap is quite loose and has abundant tissue and to spare in the direction parallel to the incision, as depicted diagrammatically in Figure 1.

The principle of the incision to be described is to take advantage of this laxity in the lower flap in such a way as to bring the central points of the flaps closer together and thus allow adequate closure with little or no undue tension, as distinct from the incisions which depend for closure on the mobility of the skin in a direction at right angles to the incision.

In the elliptical incision, the central points (Fig. 2, *A* and *B*) usually will not meet or do so with difficulty and tension.

The upper flap is formed in the usual manner. The lower flap, however, is made by two incisions forming a V, which includes the skin over the tumor, the nipple, and areola (Fig. 3).

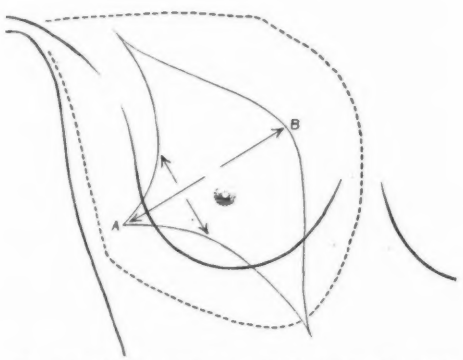
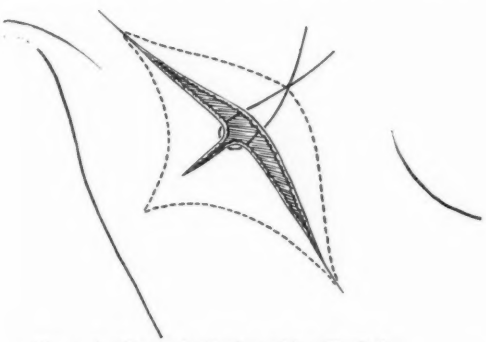


Fig. 3. Author's modification of this incision by making the lower flap V-shaped.



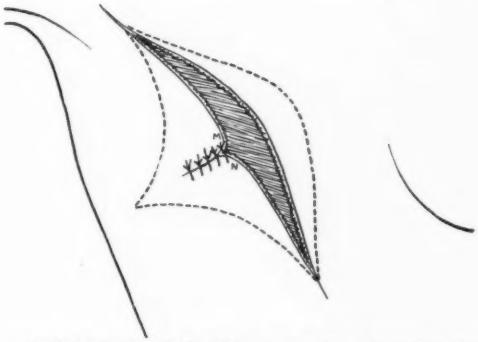


Fig. 4, A. Closure beginning with a U-stitch.
Fig. 4, B. Method of sewing up, starting at point of V and taking in the slack with sutures, thus advancing the central point of the lower toward the upper flap.

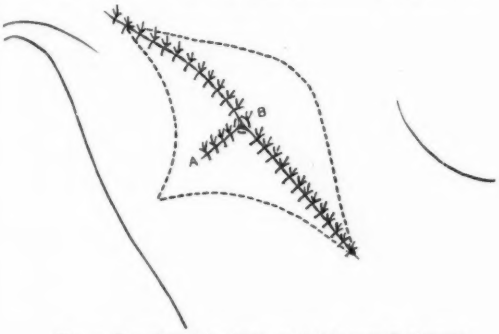


Fig. 5. The closed incision, which is now T-shaped.

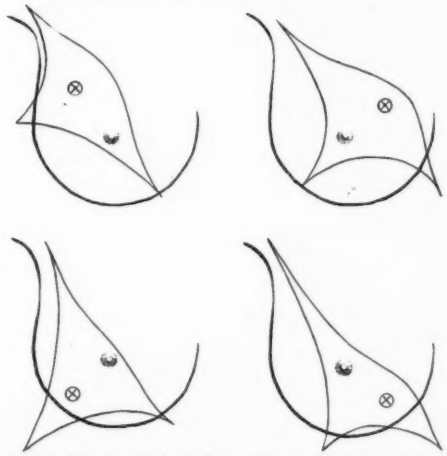


Fig. 6. The method of placing the incision according to the location of the tumor.

In closing the incision the two sides of the V come together readily. A point in the upper flap is selected to which two points on the lower flap will meet without undue tension. These three points are conveniently anchored by a U-stitch (Fig. 4, A). Closure may begin at the *point a closing* in the V until the lower flap will meet the upper without tension, (Fig. 4, B), and stopping before lateral tension begins. The upper angles of these two flaps should be rounded off to minimize the danger of sloughing.

The closed incision is now T-shaped (Fig. 5).

The site of the tumor and its relation to the nipple necessarily require consideration in the placing of the incision (Figure 6 illustrates these variations).

It is essential to know the lymph drainage of the breast and the way in which malignancy spreads in order to place the incision to insure removal of all possible involvement beyond the primary growth. Skin involvement and skin nodules (following operation) are only some of the problems of the surgery of malignant disease of the breast. The scope of this paper cannot take these into consideration.

RÉSUMÉ

1. Difficulty is often encountered in closure when an adequate skin area is removed with an incision of the elliptical type.

2. The incision described herein allows of equally free removal of skin in suitable cases and closure is simplified.

3. Skin grafting is less frequently necessary.

4. It is understood that closure of the wound is not the essential consideration when malignant growth is very extensive or has already involved the skin.

MALIGNANT MIXED TUMORS—ADENOSARCOMA OF THE CORPUS UTERI

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THE group of cases under consideration appears to be uniform in 3 respects; postmenopausal incidence, composite histology, and high malignancy. These cases are, therefore, sharply separable from the whole group of sarcomas of the uterus, which occur at all ages and are variable in histological features and in degree of malignancy and curability. Whether adenosarcomas have been hitherto grouped together with other sarcomas of the uterine corpus in the reported studies, is not possible to determine. In the group of 40 sarcomas reported by Handley and Howkins the ages ranged from 30 to 70, and the authors found a correlation between frequency of mitotic figures and fatal outcome. They were satisfied that it was practicable to distinguish cellular but benign fibromyomas from sarcoma by the preservation of the whorled pattern in the former as well as the lesser number of mitotic divisions. In the absence of any statement as to the menstrual status of their patients I have noted, that if the cases are grouped according to age, the 17 patients below the age of 50 show a group of 7 surviving the period of observation, while in the group of 23 above the age of 50 only 1 survivor is found. However, there is no evidence that any of these cases showed the composite histology found in my group.

A study of a large group of uterine sarcomas by Novak and Anderson includes only 2 cases of polypoid sarcoma, or sarcoma botryoides, both occurring in young children and rapidly fatal. The authors believe that sarcoma may arise from the uterine wall or from a fibromyoma, both of these sources furnishing myogenic tumors; and other sarcomas may arise from the mucosa, presumably the stroma cells, and from blood vessels. They found that the tumors of fibromyomatous origin yielded the most numerous clinical cures, but that in general the degree of mitotic activity was a good guide to prognosis. No mention of composite structure or of the comparative outcome of cases beyond the menopause is made.

Six cases constitute the group presented here. They were found among a total of approximately 8,500 gynecological specimens obtained in a period of 9 years. This is about one-third the incidence of all uterine sarcomas found by Novak and Anderson. All the cases presented similar clinical features: discharge, hemorrhage, passage of clots and slough, irregular pain, soreness, and feeling of pelvic weight. All had passed through the menopause 2 or more years before the onset of symptoms. Physical examination revealed palpable enlargement of the fundus and in some cases a mass partly extruding itself through the dilated cervix. This mass was usually smooth and its surface was edematous and hemorrhagic, so that the clinical impression of a degenerating submucous fibromyoma was given. Examination of slough or of a biopsy specimen was necessary for diagnosis.

The clinical course and pathological findings in the individual cases follow:

CASE 1. A single nulliparous Swedish woman of 52 years was seen first as a clinic patient. She had reached the menopause 2 years before the present illness. Four weeks prior to coming to the hospital she had occasional painful sensations in the lower abdomen followed shortly by the passage of blood and blood clots. The hemorrhage became progressively worse and 6 to 12 pads a day were required. She had noted a yellowish, odorless discharge before the bleeding but could not fix its time of onset.

Physical examination detected a moderate, poorly outlined enlargement of the fundus of the uterus. The cervical canal was patulous and bleeding, and there was a suggestion of a mass extruding itself at the internal os.

Operation on August 15, 1936, disclosed a large amount of friable material of the type usually described as "cauliflower-like." The fundus could be felt under anesthesia to be about three times its normal size. A biopsy revealed the characteristic histopathology of adenosarcoma (Fig. 1). A few irregular tubular structures of epithelial appearance were found widely separated in a pleomorphic stroma. The tubules showed their lining cells poorly oriented with small secondary acini in the walls of the larger ones. Mitotic figures were more numerous in the supporting stroma, where the cells were large and frequently of giant form with several nuclei. There were some cells with acidophilic cytoplasm resembling smooth muscle cells but greatly enlarged and with hyperchromatic and multiple nuclei.

The patient was treated by the insertion of radium in the uterine canal for a total dosage of 2,500 milligram hours. She was thought to be too anemic for further treatment and was discharged. Subsequently she was given a course of pelvic x-ray therapy at 4 ports. Readmission on January 17, 1937, found her somewhat improved, with the hemorrhage reduced to occasional spotting. The fundus was about three times its normal size and the cervix was very small and shrunken. Laparotomy on January 19, 1937, revealed multiple peritoneal adhesions

Fig. 1. Case 1. Curettage specimen shows one large and other small tubular groups of ill-differentiated epithelium, with sarcomatous stroma of polymorphous variety, but including many large acidophilic cells, apparently immature muscle.

and metastatic nodules over the omentum and the surface of the liver. Both adnexa were found covered by new-growth. A biopsy specimen of the omentum was taken but no therapeutic procedure was thought possible.

Pathological examination of the omental biopsy tissue brought out some features identical with and others dissimilar to the primary tumor. The cells (Fig. 2) appeared to be of a single type and resembled anaplastic carcinoma in their tendency to group themselves in close apposition without tubular arrangement. Spindle forms resembling the stromal masses in the first biopsy were numerous, but none of the myoblasts could be found.

This patient continued to become more feeble and had attacks of abdominal pain. She died 14 months after her first admission with evidence of widespread metastases.

Case 2. A 58 year old colored woman, nulliparous, 9 years past the menopause, came for the relief of symptoms which began about 2 years before. The principal complaints were vaginal staining, partly watery and pink, and sometimes bloody, and increasing abdominal tumor. She also had backache, rectal pain, frequency, pain in urination, and bilateral abdominal soreness. Physical examination revealed an enlargement and induration of the uterine fundus with fixation. The cervical lips were smooth but the canal was dilated with necrotic material protruding from it. The right adnexa felt indurated and enlarged. Operation on May 11, 1937, revealed a polypoid mass in the uterine cavity, and this was avulsed. It proved to be an ovoid solid mass 7.7 by 5 by 4.5 centimeters. Its surface was brown and almost smooth, but the consistency was friable. On section the tissue appeared soft and spongy with many large foci of hemorrhage but no cavities.

The histopathology of this tumor (Fig. 3) is composite. The predominant cell form is a spindle-shaped structure with poorly defined cytoplasm and ovoid clear nucleus. Scattered large cells with acidophilic cytoplasm and hyperchromatic nuclei are present. In the densest foci there are cords of large anaplastic cells. Many foci are myxomatous with smooth basophilic intercellular substance of chondroid type.

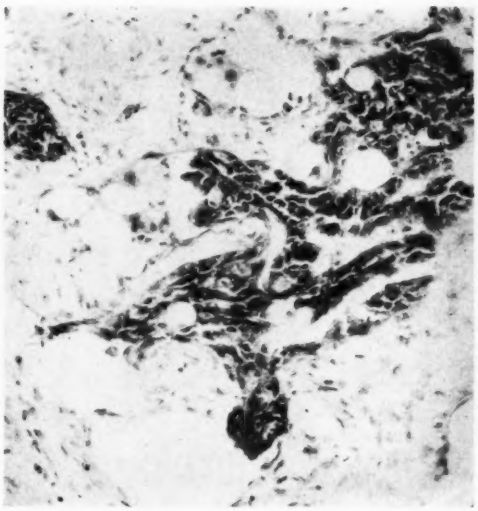

Fig. 2. Case 1. Biopsy of omentum has the structure of undifferentiated carcinoma without stroma.

This patient was considered to be too cachectic to undergo any treatment. She died of abdominal tumor extension 5 months after admission.

Case 3. A 58 year old white, married woman passed a large mass per vaginam and subsequently continued to bleed. She had passed the menopause about 5 years before, and although the present illness had been preceded

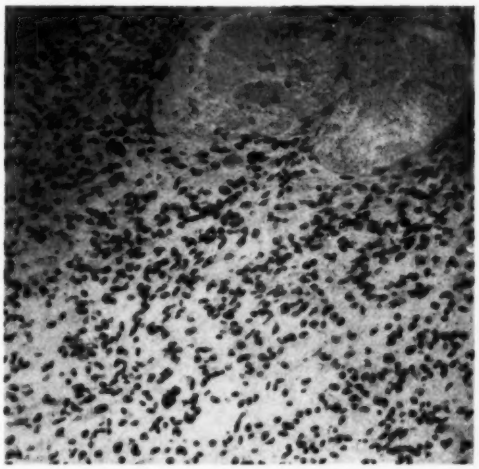

Fig. 3. Case 2. An undifferentiated ground structure of small spindle cells, scattered among which are large cells, (myoblasts) seen especially near the vessels and other cells with giant nuclei.

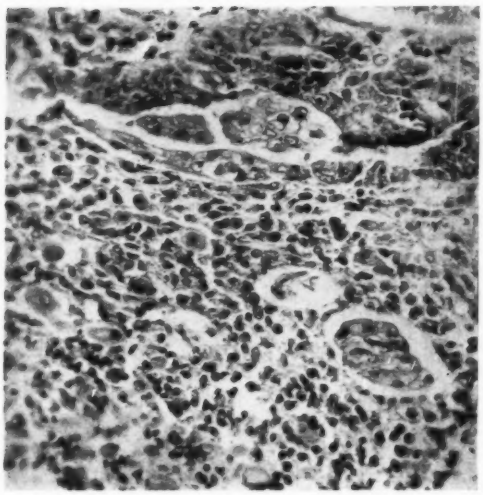

Fig. 4. Case 3. In this field are seen solid and tubular nests of carcinoma with a very cellular stroma containing undifferentiated spindle cells and large acidophilic cells which show occasional markings resembling striations.

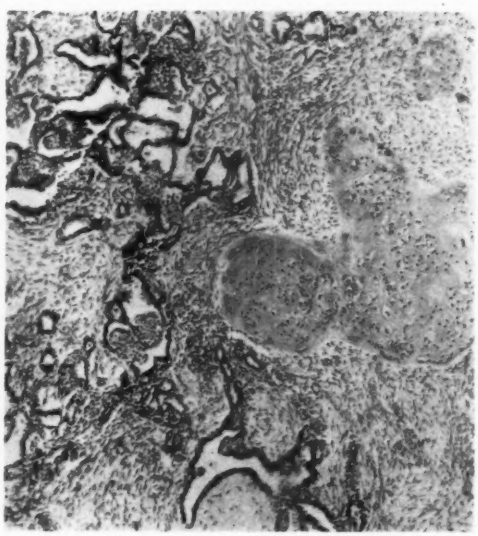

Fig. 5. Case 4. The above curettage specimen illustrates a striking admixture of cellular stroma with myxomatous foci, islands of cartilage, and epithelial tubules of irregular form.

by abdominal fulness and fatigue she had not called for medical attention. She probably had had vaginal discharge for some time, but no frank hemorrhage until the sudden protrusion and subsequent passage of the mass. Examination of the specimen showed it to be 12 by 10 by 5 centimeters, with a smooth brown surface, broken at one end by a pointed hemorrhagic zone, representing apparently the site of attachment. On section all of the tissue was soft and solid with a mixed gray-brown and red-streaked color and a fibrous texture.

Microscopic examination (Fig. 4) shows a composite histology. The supporting tissue is made up of spindle cells which are elongated and separated by clear nonfibrillary material. Among these cells are a great many larger ones which have abundant acidophilic cytoplasm and central nuclei showing hyperchromatism and scattered mitotic figures. Tubular glands are embedded in this mixed stroma and consist of poorly oriented epithelial cells with clear cytoplasm, sharp cell borders, and irregular nuclei. Many solid clusters of the epithelial cells are observed.

Laparotomy was performed in an attempt to remove the uterus and adnexal structures, but adhesions and tumor implantations were encountered over the urinary bladder and on the anterior abdominal wall. Biopsy of these revealed a marked predominance of poorly organized adenocarcinoma without the composite structure found in the uterine mass.

This patient died within 2 weeks in a sudden episode which had the clinical features of pulmonary embolism.

Case 4. This patient is presented by permission of her doctor, Dr. W. P. Healy, of whose complete records the following is an abstract. Her present complaints began 12 years after the cessation of menses when she was 63 years old. She had been seen frequently for many years because of uterine malposition, and menopause was induced at the age of 51 by intra-uterine radium application of 1000 milligram hours. At the same time the cervix was cauterized and hysteropexy was done. She became free of symptoms and was well for 8 years under observation but ceased coming for periodic examination thereafter. She returned to Dr. Healy's observation 12 years after the last menstrual period with a complaint of a brownish vaginal discharge of 3 weeks' duration. He found a zone of tenderness under the abdominal scar. The cervix was smooth with a large polyp protruding from the canal. The corpus was sensitive and enlarged to a size of about a 2½ months' pregnancy. The polyp was avulsed.

The histopathology of this polyp (Fig. 5) is typical of the composite tumors in this group. There are large tubular and branching glands, lined with one to three layers of ovoid epithelial cells, poorly oriented in relation to the lumen and showing no secretory activity. The basement membrane is not well defined. In the stroma are noted occasional whorls of spindle cells of epithelial appearance, with acidophilic cytoplasm and occasional intercellular bridges. The stroma itself is richly cellular, and the cells are large, irregular, and relatively deficient in intercellular fibrils. There are several striking foci of cartilage and other foci of myxomatous and chondroid appearance.

Treatment was instituted at once, consisting of the intra-uterine application of radium to a dosage of 3600 milligram hours and pelvic x-ray therapy, 1 cycle through 4 portals. After the elapse of 12 weeks a panhysterectomy was performed. At operation there was no evidence of tumor implantation or metastasis in the peritoneal cavity.

The gross appearance of the uterus was as follows: With the attached cervix, it measured 7.5 centimeters in length and the fundus was 5.5 centimeters broad and 3.7 centimeters in depth. The wall on section was fibrous and no nodules were to be felt or seen. The uterine canal showed a superficial zone of yellow, cheesy, opaque coagulation

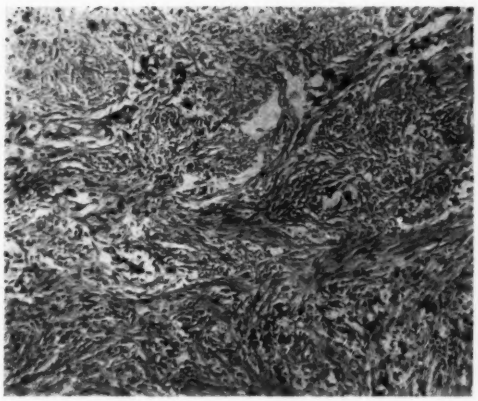

Fig. 6. Case 4. Operative specimen of the uterine wall after radiation therapy shows diffusely infiltrating tumor persisting in small strands, but without the original characteristic differentiation.

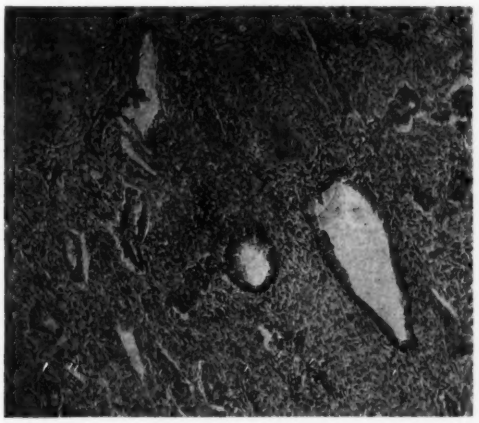

Fig. 7. Case 5. The complex architecture, partly tubular adenocarcinoma and partly cellular stroma, is seen to include in the latter many large acidophilic cells and several islands of cartilage.

occupying the place of the endometrium except at the top of the fundus where a pink smooth mucosa was present. In the middle of the uterine canal the coagulated cheesy zone involved some of the underlying myometrium to a depth of about 8 millimeters. The cervical canal was hemorrhagic and soft. The uterine tubes were of normal dimensions and fibrous consistency with a few fibrous adhesions. On section they contained a little clear fluid. The ovaries were both small, wrinkled, and fibrous on section.

Microscopic examination of the uterus (Fig. 6) shows a number of unexpected features, considering that the original tumor was polypoid, and the gross appearance of the removed uterus gave evidence of radiation necrosis of the endometrium and fibrosis of the myometrium. Beneath the zone of typical hyalinization, ischemia, and coagulation of radiation necrosis are seen a great number of finely divided cell strands, following the intramuscular vessels and penetrating into all parts of the sections. These strands consist of spindle cells and ovoid cells with basophilic cytoplasm, and they are arranged in small clusters without acinar grouping. Some cells show hyaline globules. The uterine tubes and ovaries show no tumor involvement.

During the following year the patient continued under close observation and at the end of this period a mass became palpable to the left of the sacrum. Another complete course of x-ray therapy was given, and at the present time there is no longer a palpable mass nor any evidence of tumor elsewhere.

Cases 5 and 6 have been reported in a previous paper (12). Because of their identity with the cases above, a summary of the clinical course and pathology is repeated here. The first case was observed in 1930 when the patient was 55 years old. She had had an artificial menopause induced by radium because of hemorrhage from fibroids (diagnosed clinically); she had had 4 children. After a period of 12 years of freedom from gynecological symptoms she entered the hospital complaining of backache and dysuria, and examination revealed great enlargement of the uterus. Because abundant friable material was obtained at curettage, complete abdominal hysterectomy was done. The uterus was found enlarged and globular with a weight of 1,030 grams. On section the corpus was seen distended by a pedunculated mass measuring 15 by 12 by 10 centimeters. Its surface was irregularly brown and red with some erosion. The cut surface was soft, fibrous and fatty with many small cysts and a great many focal hemorrhages and patches of necrosis. Microscopic examination (Fig. 7) of this tumor mass revealed a composite histology with islands of gland-forming epithelium resembling endometrial adenocarcinoma supported in myxomatous stroma where many large spindle cells and foci of cartilage were observed. A course of pelvic x-ray treatments was given. Intestinal obstruction began to develop about 6 months after operation and continued to become more nearly complete until November, 1931, about 14 months after operation, when the patient died. The pelvis was indurated at this time but no autopsy inspection was permitted.

Case 6, the second of the cases previously reported, was observed by Dr. W. P. Healy. This patient's symptoms began 9 years after a menopause induced by radium. She was 64 years old. Uterine hemorrhage began in June, 1930, and continued until August. Their cessation appeared to result from a course of pelvic x-ray therapy given in July, and another course was given in September. A pelvic examination done under anesthesia in October demonstrated globular enlargement of the uterus, and curettage was done. The fragments removed were necrotic. Failure of further radiation regression induced the surgeon to perform a complete hysterectomy on February 20, 1931. The uterus was not heavy, weighing 125 grams, but there was a polypoid mass filling its cavity. Its surface was yellowish red and fungating. Section across the attachment showed no line of demarcation. No tumor could be found in the adnexa. Microscopic examination of the tumor showed a structure identical with the cases here reported, with a striking admixture of spindle cell foci of sarcomatous appearance bearing large islands of cartilage. Large acidophilic cells resembling immature muscle were numerous. Many irregular tubular and solid epithelial clusters were present and could be demonstrated on the border of attachment of the tumor to the myometrium (Fig. 8). This patient had

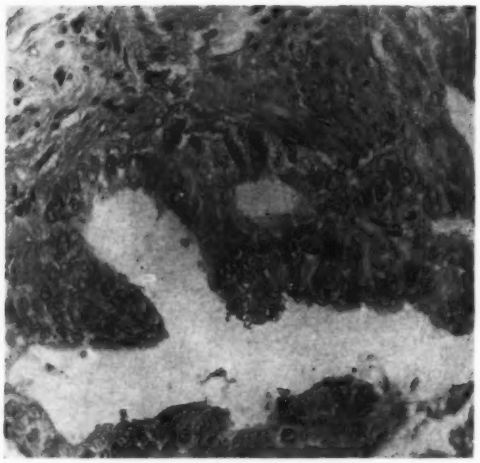

Fig. 8. Case 6. The composite structure found in this specimen is not shown here, but the border between tumor and myometrium is invasive and there are tumor stromal cells.

an uneventful and almost symptom-free course for about a year and then developed pelvic and abdominal symptoms, with clinical evidence of tumor recurrence and metastasis. She died about 2 years after the onset of symptoms and about 16 months after the operation.

SUMMARY OF CLINICAL OBSERVATIONS

The ages of the 6 patients at the time of the onset of symptoms were 52, 55, 58, 58, 63, and 64. The length of time past the menopause ranged from 2 to 12 years. The menopause had been natural in 3 cases and induced by radiation in the 3 others. The significance of the latter group is not apparent, but because of the length of time with freedom from discharge or hemorrhage it does not seem possible that the tumor found later was responsible for the symptoms requiring the induction of artificial menopause. Five of the 6 patients complained mainly of discharge or hemorrhage, and the other apparently noticed no abnormal flow. All were found to have smoothly enlarged uteri, and a polypoid mass was detected on physical examination in 4 of the patients, and was found in the 2 others when the uterus was sectioned.

In 3 patients complete hysterectomy was performed, with pre-operative radium in 1 patient together with pelvic x-ray therapy, and pre-operative x-ray therapy alone in another patient. The only patient showing some evidence of control of tumor growth was the former, and this patient appears at present free of symptoms or signs of tumor 18 months after the onset of her clinical course (Case 4). However, the uterine sections showed diffuse infiltration of the myometrium by tumor after pre-operative radium and x-ray therapy.

The 3 patients not subjected to hysterectomy were in too advanced a state for the use of effective dosage of radiation, although 2 of them had clinical complaints dating back 4 weeks or less. Biopsy of peritoneal or omental metastases was obtained in 2 of these patients and showed in them a predominance of the carcinomatous structure without the composite histology observed in the uterine tumors. However, these biopsies were so small that it is possible they did not furnish an opportunity for a complete study of the structure of the metastases. Evidence of pelvic or abdominal extension of tumor was noted at the time of the first laparotomy in 2 patients, became apparent in a short time in a patient not operated upon (Case 2), and developed in the 3 patients in whom hysterectomy was performed after intervals of 6, 12, and 16 months. In 1 patient (Case 4) it was possible to reduce the palpable pelvic tumor extension by x-ray therapy.

CASES REPORTED BY OTHERS

The variation in terminology is a serious handicap in identifying the group which is here called "adenosarcoma." Under the influence of the similarity in histology of the congenital botryoid sarcoma, these cases in adults have been reported in part as examples of the same disease. Other authors (4) have used the corresponding German term, "traubiges Sarkom," but the cases so described appear to be characterized by the polypoid and lobulated structure only and consist entirely of examples of myosarcoma and polymorphous sarcoma of the endometrium. Such cases do not appear from the data given to constitute a group with any homogeneous characteristics as to clinical course or prognosis.

Two cases showing adenocarcinoma in a stroma of spindle cell and polymorphous sarcoma were reported by Rable-Ruckhard in 1872 and their description corresponds with that of the present group. One woman was 51 years old, and the tumor was noted 14 years after the occurrence of the menopause, which must have been spontaneous although no information is given, and the second case was that of a woman of 62 years, who had passed the menopause 9 years before.

A case reported in 1890 by Klein was similar to the 2 above, and the tumor was a polypoid mass in which a mixture of myxomatous and spindle cell sarcoma supported adenocarcinoma-

tous glandular elements. The patient was 59 years old and was 11 years past the menopause.

Mention is made by Opitz of 3 cases in which the composite structure here emphasized was found. He furnishes the clinical information that 1 case was in a woman of 57 years, who had passed through the menopause 6 years previously.

Von Franque makes mention of uterine polypoid tumors with a mixed structure of sarcoma and carcinoma, but furnishes no data as to age, relationship to menopause, or prognosis, except that 1 patient was 49 years old.

Robert Meyer describes 3 categories of uterine tumor which may belong to the group with which I am concerned. One category consists of cases he considers sarcomatous changes in polypoid adenomyoma. One case was that of a woman of 50 years and the other was a patient of 67 years. Both showed polymorphous sarcoma surrounding tubular glands lined by low columnar and cuboidal epithelium. In the latter tumor there also were nests of epidermoid epithelial cells. In Meyer's second group bearing on the present problem, there are described under the title "adenosarcoma" 3 cases of polypoid tumors arising from the uterine mucosa. Two showed mixtures of carcinomatous elements with the spindle cell stroma. A distinction from adenomyomatous sarcoma is made on the ground of the presence of hyperplastic smooth muscle in the former. Clinical data are not furnished. Thirdly, under the group of "carcinosarcomas," Meyer probably includes some cases which may belong to the group here discussed. He states that "most numerous among the 51 cases of carcinosarcoma in the literature are the sarcomatous polyps, which are difficult to evaluate, since the surface or the glandular epithelium seldom is carcinomatous," or the cases refer to "polyps accidentally invaded by adjacent carcinoma."

Frankl reported a case of mixed tumor occurring in the form of a very large polyp made up of spindle sarcoma and bearing irregular carcinomatous glandular structures. The age of the patient and the outcome of the case are not given.

Shaw collected from the literature 13 cases of mixed tumor arising in the corpus of the uterus. He included only those cases in which the histology revealed cells of "embryonic" type such as immature striated muscle, or tissues of atopic variety such as cartilage. No such case was to be found in the material at St. Bartholomew's, but between 1870 and 1920 Shaw found reports of 13 cases meeting his criteria. One of these is von Franque's case, mentioned here. The ages of the patients were given in 7 of the reports as follows: 49, 50, 56, 58, 62, 62, and 75. The facts that whenever the information is available, the patients are beyond the menopause and a high malignancy and incurability of the condition exist, are particularly noted.

Wolfe reported a case which, in so far as it showed the presence of chondromatous as well as spindle cell and myxomatous structures, may be included in the present summary. The patient was 55 years old.

Frank mentions 2 cases of mixed tumor of the body of the uterus, 1 in a woman of 70 and the other in a woman "over 70." The structure was a mixture of carcinomatous glands, embryonal striped muscle, and epidermal surface epithelium. One patient died with metastases and in the other only the curettage specimen was obtained. Frank refers to another case as "accidental mingling of adenocarcinoma and polymorphous-cell sarcoma," but clinical information about this patient is not furnished.

A summary of the reported cases coming into consideration shows, therefore, that 31 cases of tumors which may fairly be called malignant mixed tumors of the corpus uteri have been observed and that the age incidence is given in 16 of these and is in a range from 49 to 75 years with no occurrence before the menopause.

HISTOPATHOLOGICAL IDENTIFICATION

The malignant mixed tumors in the group here considered appear to arise from the endometrium. The characteristic intra-uterine polypoid tumor supports this idea, as well as the usual intermixture of glandular inclusions or actual glandular and solid epithelial tumor components. However, following Shaw, I believe any uterine tumor showing multiple cell types and more particularly, myomatous, myxomatous, and chondromatous differentiation should be included. It thus becomes difficult to exclude some of the polymorphous cell sarcomas, especially if endometrial glands may still be distinguished in the invaded tissue. In my cases, however, the presence of atopic tissue and particularly of immature muscle tumor cells has made it easily possible to distinguish the tumors from the polymorphous cell variety, in which the variety in appearance of the cells arises from the presence of round, spindle, and multinucleated forms without differentiation into characteristic structure.

The histogenesis of mixed tumors in the genital tract is commonly based on some variation of Cohnheim's theory of cell rests. Wilms used the same hypothesis to account for such tumors in the genital tract as he did for the renal tumors,

namely, the presence of an indifferent portion of embryonal mesoderm from the dorsal region, which thus might include part of a myotome and account for the presence of striated muscle cells. Meyer refines this theory in believing that cell connections accidentally become established between the nephroblastema, the blastema of the pelvic wall, and the wolffian duct, and that the downward growth of the latter may thereby carry portions of the former tissues into the uterus, cervix, and vagina. These theories appear more comprehensible in the congenital and juvenile occurrence of mixed tumors. Recent experimental production of carcinoma of the uterus and cervix by estrogenic substances has been reported from a number of sources. In such work in rabbits Pierson produced by prolonged injection of folliculin in castrated animals an infiltrative tumor of carcinomatous appearance with metaplastic stroma in which islands of bone formation appeared. The fact that the mature endometrium has such potentialities may be related to the occurrence of mixed tumors without recourse to a hypothetical embryonal displacement.

CONCLUSIONS

1. A group of 6 cases is presented which is made up of examples of an unusual tumor type with a mixed structure occurring in the body of the uterus and characterized by the presence in the microscopic morphology of epithelial tubules, spindle cell sarcoma, myxomatous foci, islands of cartilage, and immature muscle.

2. All of these cases occurred in patients past the menopause.

3. Of the 16 cases of similar pathological type reported in medical literature, in which this information is given, all were postmenopausal.

4. The degree of malignancy is high and the differentiation from benign conditions, particularly submucous fibromyoma, is important so that early treatment and operation may be instituted. Radiation appears to have some therapeutic effect, but complete abdominal hysterectomy is necessary because of the tendency to diffuse myometrial permeation. One case treated by both external radiation and intra-uterine radium, and subjected to hysterectomy, has survived 18 months without clinical evidence of tumor at the end of that period.

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TRACTION IN THE TREATMENT OF FRACTURES

THE least understood, the least efficiently employed, and yet the most important factor in the treatment of fractures, is traction. Every discourse upon fracture treatment insists upon traction with manipulation, yet even when full length has been obtained at the time of primary reduction, position of the fragments is often lost in the original splint or cast because of failure to maintain the limb in full length. When manual pull or bandages with pressure are employed, traction must often be released at once because of interference with circulation or because of undue pressure on the soft parts. Even when mole skin, adhesive plaster, or a skeletal pin has been used, these may loosen at once or in a day or two if insufficient pull is being employed to maintain length and complete reduction of the fracture.

With loss of traction following primary reduction, there is a tendency toward deviation or angulation at the point of fracture as shortening of the limb occurs. Under such circumstances deformity and disability, in some degree, are inevitable. Also in such cases, which is practically always, when weight and pulley traction are relied upon, rotation of the distal portions of the fracture and the limb occurs. Especially in the leg and in compound fractures, weight and pulley or elastic traction should never be attempted. This is true even when such devices as the Sinclair skate, pins, ice tongs, or Kirschner wires are employed. And it is especially important to note that any device that is movable outside the limb permits loss of length and position to occur as well as loosening of the wires, ice tongs, etc. in the bone and irritation at the points of exit and entrance in the skin.

The answer to these difficulties is to be found, first, in the correct application of traction on the fracture table at the time of primary reduction. Under such circumstances manipulation of the fracture fragments into correct position becomes a simple matter.

Then with the introduction of pins above and below the point of fracture and the application of a plaster-of-Paris cast, length and position, as well as permanent immobilization, are assured. This plan of treatment is especially important in compound fractures in which, as we now know, disturbance for secondary dressings is unnecessary. The method applies also in the secondary reduction of fractures, either simple or compound, in which there was failure to maintain complete reduction at the time of, or following, primary treatment.

It is most important to remember that Kirschner wires, ice tongs and other devices

are less efficient than rigid pins included in casts and are likely to be unsatisfactory in these cases. Any instrument which is or becomes loose at a point outside the limb is likely to loosen in the bone also and to cause irritation or necrosis accordingly. Rigidity and immobilization of all the anatomical parts involved, as well as skeletal fixation pins, splints, and casts employed in the treatment of fractures, are of the utmost importance.

H. WINNETT ORR.

LATERAL ABERRANT THYROID TISSUE

THE appearance of lateral aberrant thyroid tissue in its position outside of the thyroid up and down the neck anterior to the sternomastoid muscles and in relation to the internal jugular veins occurs so infrequently that its diagnosis is seldom made and its dangers rarely appreciated except by those who are dealing with thyroid cases in considerable numbers. Since all lateral aberrant thyroids are papilliferous in character they are all potentially malignant. Of 36 patients upon whom we have operated for lateral aberrant thyroid tissue, malignant degeneration had already taken place in one-third of the cases. It is important, therefore, that there be a realization of the existence of these lateral developments of extrathyroid tissue, their dangers and their management.

The true origin of the thyroid gland is a median one, represented in the adult by the foramen cæcum at the apex of the circumvallate papillæ on the posterior third of the tongue from which point it descends through the base of the tongue to its position on the trachea and connected in the fetus to the point of origin by the thyroglossal tract. This tract runs before, through, or behind the hyoid bone as median fusion of that structure relates itself to the descent of the thyroid. It is along this median tract that true developmental aberrant remnants of the descending thyroid occur.

Rarely there occurs, however, aberrant thyroid tissue originating laterally from the ultimo-branchial bodies and it is with these laterally located thyroid developments that we are here concerned. Lateral aberrant thyroids occur unilaterally or bilaterally. Because they extend upward and downward from the clavicle to the mastoids in front of and beneath the anterior border of the sternomastoid muscles as soft discrete and movable gland-like structures, they are very often mistaken for enlarged cervical lymph nodes. When malignancy occurs in these laterally located nodules of aberrant thyroid tissue, metastases sometimes occur into the thyroid gland itself, with the development in that structure of a discrete thyroid nodule. When this nodule in the thyroid is removed and submitted to a pathologist not well versed in thyroid pathology, a report may be returned stating only that it is a cancer of the thyroid. This may result and has in cases sent to us at such a stage, in the assumption on the part of the operating surgeon and the attending pathologist that the primary lesion was in the thyroid and that the lateral gland-like structures represent metastases in the adjacent cervical lymph nodes when an exactly reverse situation was the fact. Likewise, the return of a report of cancer when one or more of the laterally located cervical lymph node-like structures has been removed and submitted for examination, may be confusing to those inexperienced with this lesion.

The typically papilliferous appearance of these lesions either in their primary lateral location or when they have metastasized into the thyroid should always make one suspicious that they are lateral aberrant thyroids.

The occurrence of a chain of discrete movable, non-tender, gland-like structures up and down the neck in front of the sternomastoid muscles either on one or both sides should make one suspicious of the possibility that they are lateral aberrant thyroid tissue.

It is extremely important to diagnose such lateral aberrant thyroids properly. Since in many cases they will not have already become malignant, radical dissections of both sides of the neck from the clavicles to the mastoids should be instituted against the possibility of later malignant degeneration. If malignancy has already taken place not only should both sides of the neck be completely and radically dissected with the removal of all aberrant thyroid tissue but all nodules within the thyroid itself likewise should be widely removed at the same time. Since these papilliferous tumors, often macroscopically dark in color because of hemorrhage into them, are so radiosensitive whether or not malignant degeneration has occurred, the operation should be followed by intensive high voltage x-ray radiation to both sides of the neck. In the absence of malignant degeneration, the outlook following these procedures is excellent and even when malignancy has already occurred but one patient died following this form of treatment. FRANK H. LAHEY.

MEMOIRS

HARVEY CUSHING

1869–1939

IT IS difficult for those who knew him to believe that Harvey Cushing is not still among us. His pervasive personality which penetrated into so many and such varied circles was something that seemed timeless as well as ageless, an ever living being like a dweller on Olympus who deigned to mingle with mortals. To the present generation of physicians, Dr. Cushing was a perpetual inspiration not only as the most brilliant and gifted surgeon of his time, but as teacher and investigator, author, artist, philosopher, and friend.

As if intended to carry out the variation of Shakespeare in all three of its phases:

> "Some are born great.
> Some achieve greatness.
> And some are born in Ohio,—"

Dr. Cushing was born in Cleveland on April 8, 1869, and as he himself says, "Though long away from this community (1924) I still instinctively regard it as home, and consider myself a member at least of your medical family." A long heritage of physicians was his, from father, grandfather, and great-grandfather. Small wonder then that he should write (1923): "The medical traditions of my forebears inclined me to the abnegating life of a general practitioner. To this I looked forward during my medical course . . . . and I still think there is no more satisfactory or higher calling in medicine." But before launching him on his medical career, let us pause for a moment at Yale University where he graduated with the class of '91. For three years he played varsity baseball, and became imbued with the spirit of team play. This spirit he constantly exemplified, and in exhorting the medical faculty of his alma mater at the opening of the Sterling Hall of Medicine in 1925 we hear his words: "Not alone imagination and industry are needed, but in addition what is known as the spirit of team play, unselfish loyalty to one another and to your common purposes and objects."

From the Harvard Medical School, Cushing was graduated in 1895 with the degrees of M.A. and M.D., and thereafter served as a surgical house officer at the Massachusetts General Hospital. In looking over the records which he kept of his patients during this service, drawings of operations appear as harbingers of the daily operative sketches which so beautifully and accurately enrich practically all of his brain tumor records at the Peter Bent Brigham

Hospital. In 1896 Dr. Cushing secured an appointment at the Johns Hopkins Hospital on the service of William Stewart Halsted, and although there was an abrupt and extraordinary change in the type of surgery to which he had been accustomed, he learned and quickly appreciated the vital fundamentals which the great Halsted taught—absolute hemostasis, painstaking care in the handling of tissues, and the value of closing wounds in many layers with fine silk. No one of Halsted's pupils became as accomplished in these principles as Harvey Cushing, nor did any pass them on to others more devotedly. But great as was Dr. Halsted's influence, still greater, although along different lines, was that of William Osler. It was Osler's friendship, encouragement, inspiration, and helpful criticism, that doubtless fanned the flame which in its infancy perhaps needed just this type of kindling.

After a long term residency in general surgery at Hopkins, Dr. Cushing went abroad in 1900–1901, and spent what he has termed "The happiest and most profitable year of my life." This year was passed in two physiological laboratories, that of Professor Kronecker in Berne, and with Sherrington in Liverpool. It is significant that in the former he was engaged upon a problem of intracranial pressure, and in the latter he assisted in mapping out with the electric current the motor cortex in anthropoids. Significant too, is his own remark regarding the pursuit of these problems upon which he worked "undistracted by the responsibilities of patients, with no thought, awake or asleep, beyond the single problem in hand." Early evidence this, of that power of concentration which was among his greatest faculties.

Returning to Johns Hopkins he once more joined Halsted's staff and started as an assistant in surgery in the medical school. During the next ten years he advanced to the rank of associate professor, and in 1912 was called to Boston as Moseley professor of surgery at Harvard and surgeon-in-chief to the newly finished Peter Bent Brigham Hospital. In these positions he worked and taught until the retiring age of 63, and then in 1933 he accepted the chair of Sterling professor of neurology at Yale University. In this chair, Emeritus after 1937, and as director of studies in the history of medicine he remained until his death, October 7, 1939, almost exactly six months after his 70th birthday.

These are the bare chronological facts. What was the harvest of the years? First, and foremost as he would have it, let us look at Harvey Cushing the surgeon. Having become thoroughly trained in general surgery, and doubtless fired by his investigative experiences upon the brain in animals, he had conceived the idea of developing neurological surgery as a specialty upon his return to Baltimore in 1901. Furthermore, he had seen as an interne the inadequacy and hopelessness of operations upon the brain as carried out at that time—a small trephine opening by the surgeon at a point on the patient's skull indicated by a neurologist —and of course no lesion found. Of this he says: "To every onlooker the only

way to avoid such an impasse must have been obvious. Either the surgeon would have to take greater interest in the problem through familiarizing himself with the brain and its diseases, or the neurologist would have to learn enough surgery to do the operation himself." He, therefore, set himself the task of learning neurology and from that time forward preached and practiced the doctrine that a neurological surgeon must be capable of making his own diagnosis and take the whole responsibility as to when and where to operate. In his own words: "Whatever his specialty may happen to be, it is only when a surgeon is shouldered with the responsibility of acting largely on his own diagnosis that he will be impelled seriously to study his own cases before they come to the operating table and will be inclined to follow the results of his procedures to the end to see wherein his mistakes can be rectified on subsequent occasions." How perfectly and to what an extraordinary degree Harvey Cushing carried out these dicta, all his pupils and close associates can bear witness. His "surgery" began with a most careful history of each patient, gone over in detail by himself, and he often elicited further information which might change the whole aspect of the case. The neurological examination was made personally, the other special tests reviewed, and the whole put into its proper perspective. In the later days of ventriculography the x-ray films after air injection were always scrutinized together with the roentgenologist. The operation itself was both an artistic and a technical masterpiece. No pains were too great to make the procedure perfect. His delicate handling of tissues, meticulous hemostasis, and extreme care in the closure of wounds exemplified to the highest degree the edicts of his teacher, Halsted. In the earlier days of neurosurgery, when incisions had to be closed under great tension, it was Dr. Cushing's use of the buried layer of silk in the galea that prevented wounds from breaking down with the sequelæ of a cerebral fungus, infection, and death. Time was no element with him if it was of advantage to the patient, and three to five hours at the operating table were usual for major procedures, whereas in unusually difficult operations seven or eight hours might be consumed. One must not be misled, however, into thinking that Dr. Cushing was a slow operator. When haste could be made, he made it, and woe to the assistant who might be caught napping "out in right field" as he used to say! Likewise, in an emergency from a severe hemorrhage, his courage, resourcefulness, and quick action sometimes meant life or death. But the operation did not end when the last stitch was tied and cut. The patient was often left on the operating table several hours, all night, or longer if it was thought that the movement involved in getting him to bed might be detrimental. Special nurses were secured, at his own expense if the patient could not afford them, and he himself saw the patient frequently during the first postoperative hours. Always his last act before leaving the hospital for his home was to pay a final visit to the patient. It was this unending care and the ceaseless work it entailed which

brought results. At times it seemed hard to his pupils, perhaps they thought unnecessarily hard, since they shared the work and much was expected of them. But never more than he demanded of himself, constantly, and such leadership when rightly viewed, could be nothing but an inspiration.

And what did all these pains accomplish? Just this. It reduced the mortality for operations upon the nervous system to the lowest figure in history, and gave to the patients who came under Dr. Cushing's care a better chance of being cured or relieved for a longer period than they would have had in any other hands. It not only established modern neurosurgery by carrying this surgical specialty far beyond the pioneer efforts of Sir Victor Horsley, but it inaugurated a school of neurosurgery which carried the teachings of the master to the ends of the world.

As a teacher Dr. Cushing's gifts were no less than those in other spheres. Indeed his whole attitude and conduct with patients at the bedside, his example in the operating room, and his persistence in following problems to their finish were enough and more to bring him pupils from all lands. But for the undergraduates in medical school he was equally stimulating, and his course in diagnosis and operative surgery on dogs at Johns Hopkins was the most sought after of all third year electives. At the Brigham his amphitheater clinics and lectures were prepared with the selfsame care and minute attention to detail that characterized his other activities. His ideas about medical teaching were many and came to be more frequently expressed as the years went on. Although appreciative of the value of the modern elaborate laboratory examinations he always insisted on learning all that could be learned from the clinical side first. In 1922 he said, "With the growth of this modern laboratory movement we must beware lest the student be kept too much away from the bedside, which now some of them scarcely reach until after their graduation." And from the same address: "Only by prolonged contact with the patient at the bedside can he come to take a good history, to make a proper examination, to learn to separate the wheat from the chaff of the patient's complaints."

But we must pass on to Harvey Cushing, the investigator. It is a long story—as long as his own life as it was part and parcel of it. His mind was an imaginative, inquiring thing which must "see all round" any subject with which it came into contact. Because this was so, and because he had the energy and vitality to pursue problems to their end, the world of knowledge has stepped forward faster and a vast number of human lives have been saved and distress has been alleviated. Through the years his laboratory research was linked up with his clinical investigations and experiences, and with both there entered the same spirit of inquiry, the relentless pursuit of a problem to its solution.

In a letter to the class secretary of Yale '91 and published in the 20th reunion record he writes: "I have been in a turmoil all the spring, writing a book—it

will edify you to know that it is on the familiar subject of the pituitary body and its disorders—and I promise never to do the like again." Promise indeed! It merely showed that some promises are better broken than kept. The monograph appeared in 1912 and was admittedly the last word upon all that was then known concerning the pituitary. It not only incorporated the fundamental and classical investigations of Dr. Cushing and his associates in the Hunterian Laboratory at Hopkins on the physiology of the hypophysis, but contained an imposing array of case reports and operations upon tumors of the gland, thus establishing beyond doubt the operability of these tumors and the benefits derived thereby. In the succeeding twenty years his interest in the pituitary continued unabated, frequent important papers and monographs appearing on this subject. Finally, in 1932, he described a syndrome associated with basophilic adenomas of the gland and this has become known as Cushing's disease.

But other fields in neurological surgery and its allied problems were tilled vigorously as his three hundred and more published articles and monographs so patently testify. Practically all represent important contributions. His "Surgery of the Head" in Keen's *System* in 1908 was the standard of its day. *Tumors of the Nervus Acusticus and the Syndrome of the Cerebellopontile Angle* was published as a monograph in 1917. This was revolutionary. It placed the surgery of these benign tumors on a reasonably safe surgical basis for the first time and offered a means of giving most of his patients relief of symptoms for prolonged periods. With Dr. Percival Bailey in 1926 he published, *A Classification of the Tumors of the Glioma Group on a Histogenetic Basis with a Correlated Study of Prognosis.* This was the first attempt by anyone to bring order out of chaos in this largest class of brain tumors, and to gain some knowledge of their natural history. Important studies with other collaborators on distortions of the visual fields in various types of brain tumor, and a series of studies, largely with Dr. Lewis H. Weed on the cerebrospinal fluid and its pathways came out from time to time between 1911 and 1921. Almost all the varied forms of brain tumors were dealt with individually, but more than all others the meningiomas. Finally, in 1938 in collaboration with Dr. Louise Eisenhardt his last and largest scientific monograph was published. This was, *Meningiomas. Their Classification, Regional Behaviour, Life History and Surgical End-Results.* One other monograph should be mentioned, namely, *Intracranial Tumors. Notes upon a Series of Two Thousand Verified Cases with Surgical Mortality Percentages Pertaining Thereto.* This summary of his life's work with brain tumors appeared in 1932, the year in which he retired from surgical work. These results stand today unequalled and unapproached by those of any other.

It is obviously impossible in a short memorial of this kind to do more than mention briefly a few of the highest points in a life which was so full and of such varied activity. Dr. Cushing's twenty years at the Brigham Hospital were

interrupted by two years spent in France with the British and American Expeditionary Forces, 1917–1918. With the former at 46 Casualty Clearing Station in the Ypres sector he developed and subsequently published a method of surgical treatment for gunshot wounds of the skull and brain. His method at once became a standard and reduced the mortality for such injuries to a considerable degree. In 1918 he was called to the American Forces as Senior Consultant in Neurological Surgery with the rank of colonel. He was honored with the Distinguished Service Medal by the United States, Companion of the Bath by Great Britain and Officer of the Legion of Honor by France. Throughout the war he kept a detailed diary and from this long record he wrote and published in 1936, *From a Surgeon's Journal*, a book equally fascinating to laymen and physicians.

If Harvey Cushing had never been known for anything else, his *Life of Sir William Osler* would of course have made him famous. This magnificent biography in two large volumes, winner of the Pulitzer Prize, was written at Lady Osler's request, and completed in 1925. How he managed to do this and at the same time to carry on his usual hospital duties will forever remain a mystery even to those who watched him at the task.

What were Dr. Cushing's recreations? Writing of course comes first although this may be said to have been part of his daily work. Secondly, he was from his earliest years in medicine a bibliophile, but not in any sense a mere collector of books. He had a magnificent medical library but one which "worked its passage" for himself, his pupils, and his associates. He became a profound student of the history of medicine, and to read even a handful of his papers is to become fairly familiar with the story of our profession and with those who have passed the torch. During the summer he enjoyed playing tennis two or three times a week and on Sunday afternoons many of his pupils as well as some of the house staff at the Brigham gathered at his court at 305 Walnut Street, Brookline, to play doubles turn about. Mrs. Cushing always presided at the tea table beside the court and was an inimitable hostess. Indeed, even the briefest note of Harvey Cushing's life and work would not be complete without mention of her—a perfect complement to the greatest medical figure of our time.

It is quite obvious that Dr. Cushing should be and was honored in a host of ways. He was a member of innumerable medical and surgical societies in this country and served a term as president of the American College of Surgeons, the American Surgical Association, and the American Neurological Association. He was an honorary member of countless foreign medical and scientific organizations. He held honorary fellowships in the Royal Colleges of England, Ireland, and Edinburgh and in similar organizations in France, Germany, Italy, Belgium, and other lands abroad. Honorary degrees poured in upon him from the leading universities in America and Europe. And all this he received in his own simple and modest way. As he himself said of another: "few men have ever taken so

much adulation with such an equable air almost of ignoring it." The same was true when his friends gathered to do him honor on his 60th birthday at which time the *Archives of Surgery* published a special number as a *Festschrift* containing articles by nearly all of his pupils and associates. Again, on his 70th birthday in April just passed, the Harvey Cushing Society, a group of workers in neurological fields, held their annual meeting in New Haven and were his hosts on this occasion. The "Chief" was in excellent form and seemed perhaps in as good health as he had been in recent years, better in fact than he had been during his first couple of years in New Haven when he had suffered severe pain in his legs from a combination of arterial diseases. Throughout the summer he was actively writing but died suddenly on October seventh from coronary occlusion. His burial was in Cleveland, the home of his boyhood from which as he said, "time and distance could never wholly wean us." We think of him, however, in his last years happily ensconced in his old alma mater, working and writing among his books, stimulating as ever to the faithful friends, pupils, and associates around him in an atmosphere which was wholly congenial.

Harvey Cushing will be remembered as an inspiring leader, a man who aimed at perfection in all things, and attained it in great measure by hard work, simplicity of life, and a capacity for taking infinite pains. To these he added a highly imaginative intellect and unusually keen powers of observation. He had to a magnificent degree "the crusading spirit and combative vigour necessary to force his views upon a reluctant and traditionally conservative profession." Or, as he puts it in a different way: "No idea is wholly new; what *is* new is getting people to adopt it and to act upon it." Thus he was able to "ripen his time."

"By their fruits ye shall know them." GILBERT HORRAX.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE elaborate work, *Yodoventriculografia,*[1] in which Carrillo discusses a relatively circumscribed field of neurological diagnosis has been prepared in 4 parts. The first division deals with the general fundamentals of the procedure, with emphasis on the lack of precision in the ordinary symptomatology of tumors of the posterior fossa. Fine topographical diagnosis can be of great benefit to the surgeon. Chapter III presents a review of neurosurgical methods of diagnosis, comparing the results and possibilities of each method for the localization of the surgical lesions of the posterior fossa. There is a long discussion on the relative value of air and of lipiodol as contrast media in ventriculography and a comparison of lipiodol with thorotrast. The author's technique of iodoventriculography is discussed in great detail. A number of anatomical and experimental methods are described and a mass of statistics are offered.

The second part deals with iodoventriculographic symptomatology. The various normal and pathological findings of the aqueduct of Silvius and of the third and fourth ventricles are discussed in considerable detail; in fact, all the possible alterations of the structures of the posterior fossa are adequately handled. Serial roentgenograms are recommended.

The third part deals with iodoventriculographic syndromes for the various tumors and diseases.

The fourth and final section emphasizes the value of iodoventriculography in surgery of the posterior fossa. The author is of the opinion that no surgeon who wishes to proceed conscientiously should operate on the posterior fossa without first practicing iodoventriculography. This method facilitates the differential diagnosis from supratentorial lesions, localizes the level of the tumor within the posterior fossa, and excludes the existence of a disease not associated with tumor formation.

The author's work is based on more than 550 cases, undoubtedly the largest series of its kind in the world. JAMES T. CASE.

IN *The Principles and Practice of Ophthalmic Surgery,*[2] Spaeth has given American ophthalmology a complete text on the surgery of the eye. Ophthalmology is considered as a branch of internal medicine, having a definite surgical aspect.

The work is a thoroughly practical guide to the surgery of the eye. The chapters devoted to the essentials of reconstructive ophthalmological plastic surgery are especially complete and well illustrated. This is due to the author's extensive experience in this special field and will be found most valuable. The text on keratoplasty has been written by Dr. Ramon Castroviejo, and that on goniotomy by Dr. Otto Barkan.

Diagnosis and surgical treatment are included in each group of operations. A discussion of the pathological conditions and the methods of examination necessary for the proper diagnosis are also given. Not only the author's procedure but certain other generally approved methods are included. The illustrations are profuse and most are excellent. This book is probably the most extensive and exhaustive work on ophthalmic surgery produced in the English language and is earnestly recommended to all practicing ophthalmologists. SAMUEL J. MEYER.

THE many recent advances in the management of gonorrhea are recorded in the third edition of *Gonorrhea in the Male and Female,*[3] which is a complete revision of the second edition of this work. The text is divided into 3 parts; one devoted to male infections, one to female infections, and a section on the medical profession and gonorrheal control.

The foundation for study of gonorrhea in the male is laid in a clear anatomical and histological picture. The influence of the histological structure on an initial infection and defense processes and that of anatomical structure on drainage has been carefully considered. Particularly interesting in the section on the gonococcus is the information regarding the thermal death point of the organism, especially in relation to the use of hyperthermia in the treatment of gonorrhea. The difficulties of diagnosis in gonorrhea are reiterated, and methods of culture, fixing, and staining are outlined. One entire chapter is devoted to the consideration of urethral discharges other than those due to gonorrhea.

A conservative attitude toward the results obtainable with sulfanilamide is assumed, this conclusion being drawn from tabulation of the results of many workers. The author divides his sulfanilamide patients into 3 groups: those who are absolutely cured, those who become carriers of the disease, and those who were unaffected by the drug. The dangers in the use of the drug are presented both from the standpoint of toxicity and particularly from the carrier state often produced by sulfanilamide. The necessity of local treatment in conjunction with sulfan-

[1] YODOVENTRICULOGRAFIA (FOSA POSTERIOR). By Dr. Ramon Carrillo. Buenos Aires: Frascoli y Bindi, 1937.

[2] THE PRINCIPLES AND PRACTICE OF OPHTHALMIC SURGERY. By Edmund B. Spaeth, M.D. Philadelphia: Lea & Febiger, 1939.

[3] GONORRHEA IN THE MALE AND FEMALE; A BOOK FOR PRACTITIONERS. By P. S. Pelouze, M.D. 3d rev. ed. Philadelphia and London: W. B. Saunders Co., 1939.

ilamide is emphasized. There is much logical information on treatment methods of anterior urethritis, posterior urethritis, and all of the complications, both common and rare; and, furthermore, some advance information is presented on sulfanilamide derivatives.

As in the second edition, the study of female gonorrhea is made analogous to that of male infection, and the influences of anatomy and histology are stressed. Recommendations for treatment are divided into acute, subacute, and chronic stages, and vulvar, cervical, and tubal zones. There is considerable information on the hormone treatment of vaginitis in female children.

In his consideration of the relations of the medical profession to gonorrheal control, Dr. Pelouze tabulates incidence of the disease, the attitude of the profession, treatment by pharmacists, influence of prostitution, venereal dispensaries, and the ideas of the general public on this disease. He is careful to present both sides of the picture where governmental control and the private physician are concerned. All in all this is a well written scientific contribution which has brought its subject matter up to date.

HARRY CULVER.

THE latest contribution of Dr. Georges Portmann, who is a recognized teacher and clinician from the University of Bordeaux and who has conducted special courses both in France and in the United States for many years, is *A Treatise on the Surgical Technique of Otorhinolaryngology*.[1] It is a text on the operative technique of all phases of otorhinolaryngology and is the result of a request from his many students and followers for an English translation of his surgical procedures. He has set down simply and systematically the procedures used by him in his graduate teachings at the Tondu Hospital and has attempted to make his work a "spoken" one, that is, a repetition of that which his students hear him say each day in the operating room.

The text of 675 pages is complete yet simple, clear, and concise with a minimum of extra phraseology so common in many surgical treatises. The paper is of good quality with appropriate binding. Illustrations are numerous, 475 in number, and include photographs of operating rooms as well as setups on surgical trays and tables. Many of the illustrations are invaluable, such as the mastoid operation given step by step.

Men other than otolaryngologists will find the book valuable. The plastic surgeon can find helpful hints in doing nasal surgery, and the general surgeon will find many useful suggestions regarding the administration of local anesthetics. Undoubtedly the book covers the field thoroughly and to the reviewer's knowledge it is the only complete one-volume edition in the English language.

JOHN F. DELPH.

[1] A TREATISE ON THE SURGICAL TECHNIQUE OF OTORHINOLARYNGOLOGY. By Georges Portmann. Collaborators: H. Retrouvey, J. Despons, P. Leduc, and G. Martinaud. Translation by Pierre Viole, M.D. Baltimore: William Wood & Co., 1939.

A SOMEWHAT unconventional viewpoint of the problem of angina and disease of the coronary arteries is presented by Miller in *Angina Pectoris*.[2] Dr. Miller's concepts may be suggested by a paragraph in his definition, "To our mind it is an oversimplification to look upon acute coronary occlusion and upon non-coronary angina pectoris as entirely separate entities. While clinical features seem to be somewhat different in each instance, there are more than enough common factors pointing to a common general physiological (autonomic) reaction. . . . We prefer, therefore, to consider angina pectoris a paroxysmal upheaval of central origin, and this whether the individual has normal or abnormal coronary vessels. Excepting the sequelæ of cardiovascular damage, the train of events following a sudden coronary occlusion is but one form of this paroxysmal upheaval."

In explanation of this concept the author presents a large number of charts which are concerned with the innervation of the heart and aorta and their connections with the spinal cord and brain. There is considerable doubt as to whether the author provides sufficient evidence to substantiate his beliefs.

CHAUNCEY C. MAHER.

A COMPLETE subject and author index of all the publications of the American Roentgen-Ray Society is to be found in *Consolidated Indices*.[3] This society was organized in 1900 and for a number of years the papers read at its annual meetings were published in the form of transactions. In 1906 this society began publishing an official journal known as the *American Quarterly of Roentgenology*. The name of the journal was changed in 1913 to the *American Journal of Roentgenology* which was published as a monthly journal with one volume a year until 1923, when the title was changed to the *American Journal of Roentgenology and Radium Therapy*, issued monthly and in two volumes a year. This volume represents the first attempt to compile a comprehensive index covering all these publications.

The services of Dr. George H. Smith were secured to deal with this mass of material. The excellence of the *Indices* is proof that he has accomplished this task in a praiseworthy manner. Transactions of the society, the original articles, editorials, biographical and historical sketches, and abstracts of both domestic and foreign journals have been indexed both as to subject and author. The author index is so arranged that papers appear in chronological order as to year, volume, and page. Dr. Smith states in the introductory note that the subject index is, as all

[2] ANGINA PECTORIS; NERVE PATHWAYS, PHYSIOLOGY, SYMPTOMATOLOGY, AND TREATMENT. By Heyman R. Miller, M.D. Baltimore: The Williams & Wilkins Co., 1939.

[3] CONSOLIDATED INDICES. Embracing Transactions of the American Roentgen-Ray Society (1903–1908); American Quarterly of Roentgenology, Vols. I–V (1906–1913); American Journal of Roentgenology, Vols. I–IX (1913–1922); American Journal of Roentgenology and Radium Therapy, Vols. X–XXXVIII (1923–1937), Author and Subject: 1903–1937. Compiled under the direction of the Publication Committee and the Editorial Office of the American Roentgen-Ray Society. Springfield, Ill.: Charles C. Thomas, 1939.

such indices must be, a compromise. The ideal index designed to meet every need of the user would be far too detailed and voluminous to be practical. The period of time covered by the indices (1903–1937) corresponds precisely to the period covering the inception and growth of the roentgen-ray and radium. A reasonable adjustment between the ideal and the practical has been accomplished.

The American Roentgen-Ray Society and the publisher are to be congratulated upon presenting to the medical world a complete index of its entire publications. This volume will be a most useful and time saving addition to every medical library as well as to the personal library of all radiologists and physicians interested in the use of the roentgen-ray and radium. EARL E. BARTH.

IN the revised and enlarged second edition of *Light Therapy*[1] Krusen presents chapters on the history, physics, and sources of therapeutic light, on the need for more accurate selection of therapeutic rays, physiological action, technique of application, forms of administration, and the indications for light therapy. There are then 10 concise chapters on the indications for ultra-violet radiation in various diseases. The final chapters are on the indications for luminous heat and infra-red radiation, contra-indications to light therapy, and the dangers and limitations of this type of therapy. This excellent monograph is well printed and illustrated and can be recommended highly to those interested in light therapy. JOHN S. COULTER.

A DEFINITE need exists for competent summaries of the present status of physical treatment. The author of *The 1938 Year Book of Physical Therapy*[2] has given a competent summary of the recent literature pertinent to this subject, and he is to be congratulated on his excellent work.

The first part presents the material relating to new developments in basic research and the practical applications of the various physical energies. The second part considers the present status of clinical usage of these physical agents in the various departments of medicine and surgery. Electrotherapy, artificial fever therapy, light therapy, hydrotherapy, balneotherapy and climatotherapy, mechanotherapy, and physical education are considered; but x-ray and radium, because they have become established as a separate medical specialty, are omitted.

This book fills a definite gap in medical literature as it contains a convenient source of information on the recent progress in the use of physical agents as adjuncts to medicine and surgery.

JOHN S. COULTER.

THE author of *Clinical Roentgenology of the Digestive Tract*[3] has endeavored to cover every phase of the gastro-intestinal tract in a comprehensive and concise manner and to compile all this material in one book. He has succeeded admirably. Throughout the volume Dr. Feldman discusses not only the roentgenological considerations of disease of the gastro-intestinal tract but also the clinical, surgical, and pathological aspects. As an example of this manner of presentation, in the chapter devoted to duodenal ulcer, which covers nearly 30 pages, the author discusses historical phases and etiological aspects, anatomy, pathology, roentgen findings both direct and indirect, and technique. This systematic correlation of the clinical and roentgenological findings of the various diseases greatly enhances the value of the book. Heretofore this has been accomplished only in an incomplete manner.

The book contains 1,010 pages, 358 illustrations, and 179 tables. With a few exceptions, the reproductions of roentgenograms are in the negative form. These are clear, well chosen, and instructive. Tables containing statistical data are used generously and to good advantage throughout the book. The author has covered an enormous amount of literature as attested by nearly 6 pages of references at the end of the chapter on gastric ulcer. A similar reference list appears at the end of all 220 chapters. Roentgen technique is discussed whenever pertinent.

The subject matter has been divided into the following sections: esophagus, stomach, duodenum, small intestines, colon, hernia, appendix, gall bladder, pancreas, and miscellaneous. Within each section a chapter is devoted to each affection of that particular organ. The discussion of the stomach, for instance, is divided into 51 chapters. Every phase of the stomach has been covered in a comprehensive and concise manner. The author stresses the importance of the association of the roentgenological study with the clinical aspects of the diseases of the gastro-intestinal tract. In this manner he has presented the importance of the diagnostic value of the roentgen study.

The book will be appreciated particularly by roentgenologists and gastro-enterologists but is recommended to any student or physician who wishes to learn more about the diagnostic roentgenology of the digestive tract. The book is well written, is characterized by its completeness, and is recommended without reservation. EARL E. BARTH.

AS in previous years, *The 1938 Year Book of Radiology*[4] presents the same excellent, concise, yet adequate review of the literature dealing with radiology. The articles selected for review from the literature have been wisely chosen. The editorial comments appearing at the end of selected reviews enhance the value of the book. A very interesting biographical article on the life of Roentgen by Dr. Glasser is reprinted almost in its entirety.

The publisher is to be congratulated on the excellence of the reproductions. The appearance of

[1] LIGHT THERAPY. By Frank Hammond Krusen, M.D. 2d rev. and enl. ed. New York: Paul B. Hoeber, Inc., 1937.

[2] THE 1938 YEAR BOOK OF PHYSICAL THERAPY. Edited by Richard Kovács, M.D. Chicago: The Year Book Publishers, 1938.

[3] CLINICAL ROENTGENOLOGY OF THE DIGESTIVE TRACT. By Maurice Feldman, M.D. Baltimore: William Wood & Co., 1938.

[4] THE 1938 YEAR BOOK OF RADIOLOGY. DIAGNOSIS. Edited by Charles A. Waters, M.D., and Whitmer B. Firor, M.D. THERAPEUTICS. Edited by Ira I. Kaplan, B.Sc., M.D. Chicago: The Year Book Publishers, Inc., 1938.

illustrations a page or more from the article is somewhat annoying but is no great distraction. Radiological diagnosis is divided into the following sections: osseous system, skull, sinuses, and mastoids; soft tissues; glandular system; respiratory system; cardiovascular system; gastro-intestinal system; genito-urinary system; obstetrics and gynecology; nervous system; technique; and teaching and principles of practice. Radiotherapeutics is handled in a similar manner. Sections are devoted to biology, physics, radiation in the various special fields such as neurology, ophthalmology, dermatology, otolaryngology, chest, breast, gastro-intestinal tract, gynecology, genito-urinary system, bone conditions, and radiation injuries.

Although there have been no startling new discoveries, the reviews indicate a continued expansion in the field of usefulness of the roentgen-ray. The rotary kymograph, thoracic "serioscopy," and the improved laminagraph are worthy of note. One is impressed with the vast amount of research which is being done throughout the world on cancer in an effort to ascertain the etiological factors. From the reports made on observations with supervoltage x-ray therapy one gathers the impression that the results, while hopeful, do not warrant the replacement of the usual 200 kilovolt unit procedure. The author has expressed the situation very aptly as follows: "Experience has shown that clinical skill, not mere increased voltages, makes for more cures." Radiation is rapidly gaining more and more favor in the treatment of infections as well as other benign lesions.

As the reviewer has stated in previous years, *The Year Book of Radiology* should be one of the most valuable books in the radiologist's library. The volume will be of interest to any physician who is desirous of acquainting himself with the recent advances which have been made in radiology.

EARL E. BARTH.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

A TOPOGRAPHIC ATLAS FOR X-RAY THERAPY. By Ira I. Kaplan, B.S., M.D., and Sidney Rubenfeld, B.S., M.D. Chicago, Ill.: The Year Book Publishers, Inc., 1939.

GYNECOLOGY; MEDICAL AND SURGICAL. By P. Brooke Bland, M.D., F.A.C.S. Assisted by Arthur First, M.D. 3d rev. ed. Philadelphia: F. A. Davis Co., 1939.

A TEXT-BOOK OF OCCUPATIONAL DISEASES OF THE SKIN. By Louis Schwartz, M.D., and Louis Tulipan, M.D. Philadelphia: Lea & Febiger, 1939.

SYNOPSIS OF PEDIATRICS. By John Zahorsky, A.B., M.S., F.A.C.P. Assisted by T. S. Zahorsky, B.S., M.D. 3d ed. St. Louis: The C. V. Mosby Co., 1939.

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